ANALYST'S LABORATORY COMPANION

THE ANALYST'S
LABORATORY COMPANION

A COLLECTION OF TABLES AND DATA FOR THE USE OF PUBLIC AND GENERAL ANALYSTS, AGRICULTURAL, BREWERS', AND WORKS' CHEMISTS, AND STUDENTS; TOGETHER WITH NUMEROUS EXAMPLES OF CHEMICAL CALCULATIONS AND CONCISE DESCRIPTIONS OF SEVERAL ANALYTICAL PROCESSES

BY

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PREFACE TO THE FIFTH EDITION

[illegible]

[illegible]

[illegible]

[illegible]

The [illegible] have been [illegible].

The Oils, Fats, and Waxes [illegible] with additional [illegible] pertaining to [illegible].

Several additions, [illegible] have been made to the section [illegible].

The data on Heat and Thermochemistry have been rewritten, with additions.

The following tables have also been revised and brought up to date: Melting points of Metals, [illegible] Analyses, Weights and Measures, Foreign Weights and their Equivalents, [illegible] of Common Substances, Vapour Pressure of Mercury, Sp. Gr. Tables of Sulphuric Acid and Ammonia, Standards of Sewage Effluents, etc. I have also amplified the Index.

A. E. JOHNSON.

21 PARKDALE, WOLVERHAMPTON,
October 1920.

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THE
ANALYST'S LABORATORY COMPANION.

THE INTERNATIONAL ATOMIC WEIGHTS FOR 1921

(USED THROUGHOUT THE WORK.)

		O = 16			O = 16
Aluminium	Al	27·1	Molybdenum	Mo	96
Antimony	Sb	120·2	Neodymium	Nd	144·3
Argon	A	39·9	Neon	Ne	20·2
Arsenic	As	74·96	Nickel	Ni	58·68
Barium	Ba	137·37	Niton (radium emanation)	Nt	222·4
Bismuth	Bi	208	Nitrogen	N	14·01
Boron	B	10·9	Osmium	Os	190·9
Bromine	Br	79·92	Oxygen	O	16
Cadmium	Cd	112·4	Palladium	Pd	106·7
Caesium	Cs	132·81	Phosphorus	P	31·04
Calcium	Ca	40·07	Platinum	Pt	195·2
Carbon *	C	12·00	Potassium	K	39·1
Cerium	Ce	140·25	Praseodymium	Pr	140·9
Chlorine	Cl	35·46	Radium	Ra	226
Chromium	Cr	52	Rhodium	Rh	102·9
Cobalt	Co	58·97	Rubidium	Rb	85·45
Columbium	Cb	93·1	Ruthenium	Ru	101·7
Copper	Cu	63·57	Samarium	Sa	150·4
Dysprosium	Dy	162·5	Scandium	Sc	45·1
Erbium	Er	167·7	Selenium	Se	79·2
Europium	Eu	152	Silicon	Si	28·3
Fluorine	F	19	Silver	Ag	107·88
Gadolinium	Gd	157·3	Sodium	Na	23
Gallium	Ga	70·1	Strontium	Sr	87·63
Germanium	Ge	72·5	Sulphur	S	32·06
Glucinum	Gl	9·1	Tantalum	Ta	181·5
Gold	Au	197·2	Tellurium	Te	127·5
Helium	He	4·0	Terbium	Tb	159·2
Hydrogen	H	1·008	Thallium	Tl	204
Indium	In	114·8	Thorium	Th	232·15
Iodine	I	126·92	Thulium	Tm	168·5
Iridium	Ir	193·1	Tin	Sn	118·7
Iron	Fe	55·84	Titanium	Ti	48·1
Krypton	Kr	82·92	Tungsten	W	184
Lanthanum	La	139	Uranium	U	238·2
Lead	Pb	207·2	Vanadium	V	51
Lithium	Li	6·94	Xenon	Xe	130·2
Lutecium	Lu	175	Ytterbium (Neoytterbium)	Yb	173·5
Magnesium	Mg	24·32	Yttrium	Yt	89·33
Manganese	Mn	54·93	Zinc	Zn	65·37
Mercury	Hg	200·6	Zirconium	Zr	90·6

For carbon and nitrogen the atomic weights 12 and 14·01, respectively, have been retained in all tables in this book because the latest values would make no appreciable difference in any ordinary calculations.

COMMON LOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
0	0	00432	00860	01284	01703	02119	02531	02938	03342	03743									
1	04139	04532	04922	05308	05690	06070	06446	06819	07188	07555									
2	07918	08279	08636	08991	09342	09691	10037	10380	10721	11059									
3	11394	11727	12057	12385	12710	13033	13354	13672	13988	14301									
4	14613	14922	15229	15534	15836	16137	16435	16732	17026	17319									
5	17609	17898	18184	18469	18752	19033	19312	19590	19866	20140									
6	20412	20683	20952	21219	21484	21748	22011	22272	22531	22789									
7	23045	23300	23553	23805	24055	24304	24551	24797	25042	25285									
8	25527	25768	26007	26245	26482	26717	26951	27184	27416	27646									
9	27875	28103	28330	28556	28780	29003	29226	29447	29667	29885									
20	30103	30320	30535	30750	30963	31175	31387	31597	31806	32015	21	42	63	84	106	127	148	170	191
21	32222	32428	32634	32838	33041	33244	33445	33646	33846	34044	20	40	61	81	101	121	141	162	182
22	34242	34439	34635	34830	35025	35218	35411	35603	35793	35984	19	39	58	77	97	116	135	154	174
23	36173	36361	36549	36736	36922	37107	37291	37475	37658	37840	18	37	55	74	92	111	129	148	166
24	38021	38202	38382	38561	38739	38917	39094	39270	39445	39620	18	35	53	71	89	106	124	142	160
25	39794	39967	40140	40312	40483	40654	40824	40993	41162	41330	17	34	51	68	85	102	119	136	153
26	41497	41664	41830	41996	42160	42325	42488	42651	42813	42975	16	33	49	66	82	98	115	131	148
27	43136	43297	43457	43616	43775	43933	44091	44248	44404	44560	16	32	47	63	79	95	111	126	142
28	44716	44871	45025	45179	45332	45484	45637	45788	45939	46090	15	30	46	61	76	91	107	122	137
29	46240	46389	46538	46687	46835	46982	47129	47276	47422	47567	15	29	44	59	74	88	103	118	132

COMMON LOGARITHMS (*continued*)

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
30	47712	47857	48001	48144	48287	48430	48572	48714	48855	48996	14	29	43	57	71	86	100	114	128
31	49136	49276	49415	49554	49693	49831	49969	50106	50243	50379	14	28	41	55	69	83	97	110	124
32	50515	50651	50786	50920	51055	51188	51322	51455	51587	51720	13	27	40	53	67	80	93	107	120
33	51851	51983	52114	52244	52375	52504	52634	52763	52892	53020	13	26	39	52	65	78	91	104	117
34	53148	53275	53403	53529	53656	53782	53908	54033	54158	54283	13	25	38	50	63	76	88	101	113
35	54407	54531	54654	54777	54900	55023	55145	55267	55388	55509	12	24	37	49	61	73	86	98	110
36	55630	55751	55871	55991	56110	56229	56348	56467	56585	56703	12	24	36	48	59	71	83	95	107
37	56820	56937	57054	57171	57287	57403	57519	57634	57749	57864	12	23	35	46	58	69	81	93	104
38	57978	58092	58206	58320	58433	58546	58659	58771	58883	58995	11	23	34	45	56	68	79	90	102
39	59106	59218	59329	59439	59550	59660	59770	59879	59988	60097	11	22	33	44	55	66	77	88	99
40	60206	60314	60423	60531	60638	60746	60853	60959	61066	61172	11	21	32	43	54	64	75	86	97
41	61278	61384	61490	61595	61700	61805	61909	62014	62118	62221	10	21	31	42	52	63	73	84	94
42	62325	62428	62531	62634	62737	62839	62941	63043	63144	63246	10	20	31	41	51	61	72	82	92
43	63347	63448	63548	63649	63749	63849	63949	64048	64147	64246	10	20	30	40	50	60	70	80	90
44	64345	64444	64542	64640	64738	64836	64933	65031	65128	65225	10	20	29	39	49	59	68	78	88
45	65321	65418	65514	65610	65706	65801	65896	65992	66087	66181	10	19	29	38	48	57	67	76	86
46	66276	66370	66464	66558	66652	66745	66839	66932	67025	67117	9	19	28	37	47	56	65	75	84
47	67210	67302	67394	67486	67578	67669	67761	67852	67943	68034	9	18	27	37	46	55	64	73	82
48	68124	68215	68305	68395	68485	68574	68664	68753	68842	68931	9	18	27	36	45	54	63	72	81
49	69020	69108	69197	69285	69373	69461	69548	69636	69723	69810	9	18	26	35	44	53	61	70	79

Note. The tabular values of numbers 1 to 10 are the same as those of 10, 20, 30, etc.

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
50	69897	69984	70070	70157	70243	70329	70415	70501	70586	70672	9	17	26	34	43	52	60	69	77
51	70757	70842	70927	71012	71096	71181	71265	71349	71433	71517	8	17	25	34	42	50	59	67	76
52	71600	71684	71767	71850	71933	72016	72099	72181	72263	72346	8	16	25	33	41	49	58	66	74
53	72428	72509	72591	72673	72754	72835	72916	72997	73078	73159	8	16	24	32	41	49	57	65	73
54	73239	73320	73400	73480	73560	73640	73719	73799	73878	73957	8	16	24	32	40	48	56	64	72
55	74036	74115	74194	74273	74351	74429	74507	74586	74663	74741	8	16	23	31	39	47	55	63	70
56	74819	74896	74974	75051	75128	75205	75282	75358	75435	75511	8	15	23	31	38	46	54	62	70
57	75587	75664	75740	75815	75891	75967	76042	76118	76193	76268	8	15	23	30	38	45	53	60	68
58	76343	76418	76492	76567	76641	76716	76790	76864	76938	77012	7	15	22	30	37	45	52	59	67
59	77085	77159	77232	77305	77379	77452	77525	77597	77670	77743	7	15	22	29	37	44	51	58	66
60	77815	77887	77960	78032	78104	78176	78247	78319	78390	78462	7	14	22	29	36	43	50	57	65
61	78533	78604	78675	78746	78817	78888	78958	79029	79099	79169	7	14	21	28	35	42	49	56	63
62	79239	79309	79379	79449	79518	79588	79657	79727	79796	79865	7	14	21	28	35	41	48	55	62
63	79934	80003	80072	80140	80209	80277	80346	80414	80482	80550	7	14	21	27	34	41	48	55	62
64	80618	80686	80754	80821	80889	80956	81023	81090	81158	81224	7	13	20	27	34	40	47	54	60
65	81291	81358	81425	81491	81558	81624	81690	81757	81823	81889	7	13	20	26	33	40	46	53	59
66	81954	82020	82086	82151	82217	82282	82347	82413	82478	82543	7	13	20	26	33	39	46	52	59
67	82607	82672	82737	82802	82866	82930	82995	83059	83123	83187	6	13	19	26	32	39	45	52	58
68	83251	83315	83378	83442	83506	83569	83632	83696	83759	83822	6	13	19	25	32	38	44	51	57
69	83885	83948	84011	84073	84136	84198	84261	84323	84386	84448	6	12	19	25	31	37	44	50	56

COMMON LOGARITHMS—(continued.)

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
70	84510	84572	84634	84696	84757	84819	84880	84942	85003	85065	6	12	18	25	31	37	43	49	55
71	85126	85187	85248	85309	85370	85431	85491	85552	85612	85673	6	12	18	24	30	36	42	49	55
72	85733	85794	85854	85914	85974	86034	86094	86153	86213	86273	6	12	18	24	30	36	42	48	54
73	86332	86392	86451	86510	86570	86629	86688	86747	86806	86864	6	12	18	24	30	35	41	47	53
74	86923	86982	87040	87099	87157	87216	87274	87332	87390	87448	6	12	17	23	29	35	41	47	52
75	87506	87564	87622	87679	87737	87795	87852	87910	87967	88024	6	12	17	23	29	35	40	46	52
76	88081	88138	88195	88252	88309	88366	88423	88480	88536	88593	6	11	17	23	28	34	40	45	51
77	88649	88705	88762	88818	88874	88930	88986	89042	89098	89154	6	11	17	22	28	34	39	45	50
78	89209	89265	89321	89376	89432	89487	89542	89597	89653	89708	6	11	17	22	28	33	39	44	50
79	89763	89818	89873	89927	89982	90037	90091	90146	90200	90255	5	11	16	22	27	33	38	44	49
80	90309	90363	90417	90472	90526	90580	90634	90687	90741	90795	5	11	16	22	27	32	38	43	49
81	90849	90902	90956	91009	91062	91116	91169	91222	91275	91328	5	11	16	21	27	32	37	43	48
82	91381	91434	91487	91540	91593	91645	91698	91751	91803	91855	5	11	16	21	26	32	37	42	47
83	91908	91960	92012	92065	92117	92169	92221	92273	92324	92376	5	10	16	21	26	31	36	42	47
84	92428	92480	92531	92583	92634	92686	92737	92788	92840	92891	5	10	15	21	26	31	36	41	46
85	92942	92993	93044	93095	93146	93197	93247	93298	93349	93399	5	10	15	20	25	30	36	41	46
86	93450	93500	93551	93601	93651	93702	93752	93802	93852	93902	5	10	15	20	25	30	35	40	45
87	93952	94002	94052	94101	94151	94201	94250	94300	94349	94399	5	10	15	20	25	30	35	40	45
88	94448	94498	94547	94596	94645	94694	94743	94792	94841	94890	5	10	15	20	25	29	34	39	44
89	94939	94988	95036	95085	95134	95182	95231	95279	95328	95376	5	10	15	19	24	29	34	39	44

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34	38	43
91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43
92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41
96	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
98	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
99	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
102	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
103	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
104	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	38
105	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
106	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37
107	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
108	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
109	[illegible]	[illegible]	03822	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35
111	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
112	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
113	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
114	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	27	30	34
115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	06371	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	34
116	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	06744	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	[illegible]
117	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	[illegible]
118	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
119	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	11	15	18	22	[illegible]	[illegible]	33
120	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
121	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	[illegible]	[illegible]	[illegible]	21	[illegible]	[illegible]	[illegible]
122	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
123	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	09167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
124	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31
125	09691	[illegible]	[illegible]	[illegible]	[illegible]	09861	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
126	10037	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	10	14	17	21	[illegible]	[illegible]	31
127	10380	10415	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	17	21	[illegible]	27	31
128	10721	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	31
129	[illegible]	[illegible]	11126	11160	11193	[illegible]	11261	[illegible]	[illegible]	11361	3	7	10	13	17	20	23	27	30

COMMON LOGARITHMS (continued)

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
130	11394	11428	11461	11494	[illegible]	11561	11594	11628	11661	11694	3	[illegible]	[illegible]	13	17	20	[illegible]	27	30
131	[illegible]	11760	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
132	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29
133	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
134	[illegible]	[illegible]	12775	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
135	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
136	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
137	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
138	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
139	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
140	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28
141	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
142	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
143	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27
144	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27
145	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21	24	27
146	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
147	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26
148	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26
149	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26

COMMON LOGARITHMS (continued)

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
150	17609	17638	17667	[illegible]	[illegible]	[illegible]	17782	17811	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26
151	17898	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
152	18184	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
153	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
154	18752	18780	18808	[illegible]	18865	[illegible]	18921	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22	25
155	19033	19061	19089	[illegible]	[illegible]	[illegible]	[illegible]	19229	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17	[illegible]	22	[illegible]
156	19312	19340	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	6	8	[illegible]	14	[illegible]	[illegible]	[illegible]	25
157	19590	19618	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19811	[illegible]	3	[illegible]	8	[illegible]	[illegible]	17	[illegible]	[illegible]	25
158	19866	19893	19921	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	5	8	11	[illegible]	[illegible]	[illegible]	[illegible]	25
159	20140	20167	20194	[illegible]	[illegible]	[illegible]	[illegible]	20330	[illegible]	20385	3	5	8	11	[illegible]	[illegible]	[illegible]	[illegible]	25
160	20412	20439	20466	20493	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20656	3	[illegible]	[illegible]	11	[illegible]	16	[illegible]	22	24
161	20683	20710	20737	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	11	[illegible]	16	[illegible]	[illegible]	24
162	[illegible]	20978	[illegible]	21032	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21192	3	5	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
163	21219	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21431	[illegible]	3	5	8	[illegible]	[illegible]	16	[illegible]	[illegible]	[illegible]
164	21484	21511	[illegible]	[illegible]	21590	21617	[illegible]	[illegible]	[illegible]	[illegible]	3	5	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
165	21748	[illegible]	[illegible]	21827	[illegible]	[illegible]	21906	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	16	[illegible]	[illegible]	24
166	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22141	[illegible]	22194	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	16	[illegible]	[illegible]	[illegible]
167	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
168	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
169	[illegible]	22814	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
170	23045	23070	23096	[illegible]	23147	23172	[illegible]	23223	23249	23274	3 5 8	10 13 15	18 20 23
171	[illegible]	23325	23350	[illegible]	23401	23426	[illegible]	23477	[illegible]	[illegible]	3 5 8	10 13 15	18 20 23
172	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23679	23704	[illegible]	23754	[illegible]	3 5 8	10 13 15	18 20 23
173	[illegible]	23830	[illegible]	23880	[illegible]	23930	[illegible]	23980	24005	[illegible]	[illegible]	10 13 [illegible]	18 20 23
174	[illegible]	24080	[illegible]	[illegible]	24155	24180	24204	[illegible]	24254	[illegible]	2 5 7	10 12 15	17 20 22
175	24304	[illegible]	24353	[illegible]	24403	24428	24452	24477	[illegible]	24527	[illegible] 7	10 12 15	[illegible]
176	24551	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24724	24748	24773	[illegible]	10 12 15	17 [illegible]
177	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24993	[illegible]	2 5 7	[illegible]	17 [illegible]
178	25042	[illegible]	25091	25115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25261	[illegible]	[illegible]	17 19 22
179	[illegible]	[illegible]	25334	[illegible]	[illegible]	25406	[illegible]	[illegible]	[illegible]	25503	[illegible]	[illegible]	[illegible] 22
180	[illegible]	[illegible]	25575	25600	[illegible]	[illegible]	[illegible]	[illegible]	25720	[illegible]	[illegible]	[illegible]	17 19 22
181	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 14	17 19 22
182	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26174	26198	[illegible]	[illegible]	[illegible]	17 19 21
183	[illegible]	[illegible]	[illegible]	[illegible]	26340	[illegible]	[illegible]	26411	26435	[illegible]	[illegible]	[illegible]	17 19 21
184	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16 19 21
185	26717	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16 19 21
186	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
187	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
188	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16 18 21
189	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9 11 14	16 18 21

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
190	27875	27898	[illegible]	[illegible]	[illegible]	27989	28012	[illegible]	[illegible]	[illegible]	[illegible]	9 11 14	16 18 21
191	[illegible]	28126	28149	28171	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28307	[illegible]	9 11 14	16 18 20
192	[illegible]	[illegible]	28375	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28511	[illegible]	[illegible]	9 11 14	16 18 20
193	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28713	[illegible]	[illegible]	[illegible]	9 11 13	16 18 20
194	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2 4 7	9 11 13	16 18 20
195	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29181	[illegible]	2 4 7	9 11 13	16 18 20
196	29226	[illegible]	29270	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29403	[illegible]	2 4 7	9 11 13	15 18 20
197	[illegible]	29469	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2 4 7	9 11 13	15 18 20
198	29667	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29863	2 4 7	9 11 13	15 18 20
199	[illegible]	29907	29929	[illegible]	[illegible]	[illegible]	30016	30038	30060	30081	2 4 7	9 11 13	15 17 20

Base of Common Logarithms = 10.

Hyp. Log. z = $\frac{1}{M}$ Com. Log. z.

Base of Hyperbolic Logarithms = e = 2·71828

Com. Log. z = M Hyp. Log. z.

Number.	Com. Log.	Number.	Com. Log.
e = 2·71828	0·434 2945	π = 3·14159	0·497 1499
$\frac{1}{M}$ = 2·30259	0·362 2157	$\frac{\pi}{4}$ = 0·785398	$\bar{1}$·895 0899
M = 0·43429	$\bar{1}$·637 7843	$\frac{\pi}{6}$ = 0·52359	$\bar{1}$·718 9986
		$\sqrt{\pi}$ = 1·77245	0·248 6749

DENSITIES OF GASES.

(The observed densities are given in this Table.)

Name of Gas.	Formula.	Molecular Weight.	Weight of 1 litre at 0° and 760 mm. bar. (grams)	Logarithms.	Observer.
Acetylene	C_2H_2	[illegible]	[illegible]	0·075 [illegible]	Berthelot
Ammonia	NH_3	17·03[illegible]	[illegible]	1·886 [illegible]	Perman & Davies
Atmospheric air	...		[illegible]	0·111 5313	Rayleigh
Carbon monoxide	CO	28	[illegible]	[illegible]	,,
,, dioxide	CO_2	[illegible]	[illegible]	[illegible]	,,
Chlorine	Cl_2	[illegible]	[illegible]	[illegible]	Treadwell
Ethylene	C_2H_4	[illegible]	[illegible]	[illegible] 0671	Saussure
Hydrogen	H_2	[illegible]	[illegible]	[illegible]	Rayleigh
Hydrogen chloride	HCl	[illegible]	[illegible]	[illegible]	Gray and Burt
,, sulphide	H_2S	[illegible]	[illegible]	[illegible]	Leduc
Methane	CH_4	[illegible]	[illegible]	[illegible]	Thomson
Nitrogen	N_2	[illegible]	[illegible]	[illegible]	Rayleigh, Gray
Nitrous oxide	N_2O	[illegible]	[illegible]	[illegible]	Rayleigh
Nitric oxide	NO	[illegible]	[illegible]	[illegible]	Gray
,, peroxide	NO_2	[illegible]	[illegible]	[illegible]	
Oxygen	O_2	32	[illegible]	[illegible]	Rayleigh
Sulphur dioxide	SO_2	64·07	[illegible]	[illegible]	Leduc and others

Note.—[illegible] litres at N.T.P. [illegible] 1000 cubic feet of [illegible] lb.

Addendum.—[illegible] litre of [illegible] at N.T.P. [illegible] grains (Regnault).

TABLE OF FREEZING MIXTURES.

A mixture of (parts by weight)	Temperature produced.
Snow or broken ice, 2; common salt, 1	−18° C.
,, ,, 3; calcium chloride (cryst.), [illegible]	[illegible] C.
Sodium sulphate (cryst.), 8; muriatic acid, [illegible]	[illegible] C.
,, phosphate (cryst.), 9; nitric acid, [illegible]	29° C.
Ammonium nitrate, 1; water, [illegible]	16° C.
Ammonium chloride, 5; saltpetre, 5; sodium sulphate, 8; water, 16	−20° C.

Note.—The solids used should be finely powdered.

MELTING-POINTS OF METALS.

Metal	Melting Point	Observer
	C°	
Aluminium	657	Holborn and Day
Antimony	630	"
Bismuth	269	Callendar
Cadmium	321	Holborn and Day
Chromium	1520	Bureau of Standards
Cobalt	1480	"
Copper	1082	Holborn and Day
Gold	1063	"
Cast iron	[illegible]	Hester
Lead	327	Holborn and Day.
Lithium	180	Bernini and Cantoni
Magnesium	632	Heycock and Neville
Manganese	1260	Bureau of Standards
Mercury (B.P. 356.7)	-38.8	Chappuis
Molybdenum	2450	Pirani and Meyer
Nickel	1452	Burgess and Waltenberg
Osmium	2700	
Platinum	1750	Various
Potassium	62.5	Holt and Sims.
Silver	961	Holborn and Day
Sodium	97.6	Bernini and Cantoni
Tin	232	Heycock and Neville.
Tungsten	3260	Langmuir.
Zinc	418	Day and Sosman.

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS.

Element.	Found as	Sought.	Factor.	Logarithm.
	ALUMINIUM (Al = 27·1).			
Al	Al_2O_3 [illegible]	Al_2	0·53033	1̄·724 55
,,	,,	[illegible]	8·87[illegible]	0·948 [illegible]
,,	,,	[illegible]	[illegible]	0·967 83
,,	$AlPO_4$	Al_2O_3	0·41837	1̄·621 56
,,	,,	[illegible]	3·71274	0·569 69
,,	[illegible]	[illegible]	[illegible]	1·019 71
	AMMONIUM (see under NITROGEN).			
	ANTIMONY (Sb = 120·2).			
Sb	Sb_2O_4 [illegible]	Sb_2	0·78975	1̄·897 49
,,	Sb_2S_3	Sb_2	0·71424	1̄·853 85
,,	,,	Sb_2O_4	0·90440	1̄·956 56
	ARSENIC (As = 74·96).			
As	$2NH_4MgAsO_4 . H_2O$ [illegible]	As_2	0·39384	1̄·595 32
,,	,,	As_2O_3	0·51994	1̄·715 93
,,	,,	As_2O_5	0·60409	1̄·781 04
,,	$Mg_2As_2O_7$	As_2	0·48271	1̄·683 71
,,	,,	As_2O_3	0·63730	1̄·804 34
,,	,,	As_2O_5	0·74034	1̄·869 43
,,	As_2O_3	As_2	0·75748	1̄·879 37
,,	As_2S_3	As_2	0·60918	1̄·784 75
,,	,,	As_2O_3	0·80423	1̄·905 36
,,	,,	As_2O_5	0·93425	1̄·970 47

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*)
	BARIUM (Ba = 137·37)				
Ba	$BaSO_4$	into	Ba	0·58846	1̄·769 72
,,	,,	,,	BaO	0·65700	1̄·817 57
,,	,,	,,	$BaCO_3$	0·84548	1̄·927 11
,,	,,	,,	$BaCl_2$	0·89226	1̄·950 49
,,	,,	,,	$BaCl_2$, $2H_2O$	1·04662	0·019 79
,,	,,	,,	S	0·13734	1̄·137 81
,,	,,	,,	SO_3	0·34300	1̄·535 26
,,	,,	,,	SO_4	0·41154	1̄·614 41
,,	,,	,,	H_2SO_4	0·42018	1̄·623 44
,,	,,	,,	$CaSO_4$	0·58319	1̄·765 81
,,	,,	,,	$CaSO_4$, $2H_2O$	0·73754	1̄·867 79
,,	,,	,,	$FeSO_4$, $7H_2O$	1·19100	0·075 90
,,	,,	,,	$PbSO_4$	1·29920	0·113 67
,,	,,	,,	$MgSO_4$	0·51572	1̄·712 42
,,	,,	,,	K_2SO_4	0·74653	1̄·873 05
,,	,,	,,	Na_2SO_4	0·60859	1̄·784 33
,,	,,	,,	Na_2SO_4, $10H_2O$	1·38035	0·139 99
,,	,,	,,	$(NH_4)_2SO_4$	0·56612	1̄·752 89
,,	$2BaSO_4$	,,	FeS_2	0·25698	1̄·409 85
,,	$4BaSO_4$	,,	$Al_2(NH_4)_2(SO_4)_4$, $24H_2O$	0·97129	1̄·987 35
,,	$BaCO_3$	,,	Ba	0·69600	1̄·842 61
,,	,,	,,	BaO	0·77707	1̄·890 46
,,	,,	,,	CO_2	0·30400	1̄·482 87
	BISMUTH (Bi = 208)				
Bi	Bi_2O_3	into	Bi_2	0·89655	1̄·952 58
,,	Bi_2S_3	,,	Bi_2	0·81222	1̄·909 67

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element	To convert			Factor	Logarithm. [illegible]
	Boron (B = 10·9)				
B	B_2O_3	into	B	0·31232	1̄·494 60
,,	B_2O_3	,,	$2H_3BO_3$	1·7713	0·249 03
,,	$2H_3BO_3$	,,	B_2O_3	0·56359	1̄·750 97
	Cadmium (Cd = 112·4)				
Cd	CdO	into	Cd	0·87529	1̄·942 20
,,	CdS	,,	Cd	0·77801	1̄·890 99
,,	,,	,,	CdO	0·88877	1̄·948 79
	Calcium (Ca = 40·07)				
Ca	CaO	into	Ca	0·71464	1̄·854 09
,,	,,	,,	$CaCO_3$	1·78173	0·251 57
,,	,,	,,	$CaSO_4$	2·42804	0·385 22
,,	,,	,,	$CaSO_4, 2H_2O$	3·07050	0·487 21
,,	,,	,,	$CaCl_2$	1·97919	0·296 55
,,	,,	,,	CaH_2O_2	1·32131	0·121 01
,,	3CaO	,,	$Ca_3P_2O_8$	1·84166	0·265 21
,,	$CaCl_2$	,,	CaO	0·50518	1̄·703 45
,,	,,	,,	Cl_2	0·63897	1̄·805 48
,,	$CaCO_3$	,,	Ca	0·40042	1̄·602 52
,,	,,	,,	CaO	0·56039	1̄·748 43
,,	,,	,,	CO_2	0·43969	1̄·643 15
,,	,,	,,	CO_3	0·59958	1̄·777 85
,,	,,	,,	$CaSO_4$	1·36010	0·133 65
,,	,,	,,	$CaSO_4, 2H_2O$	1·72040	0·235 63
,,	$CaSO_4$	,,	Ca	0·29433	1̄·468 83
,,	,,	,,	CaO	0·41186	1̄·614 71
,,	,,	,,	$CaCO_3$	0·73505	1̄·866 32

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert	[illegible]	Factor	Logarithm (to be added).
CALCIUM (Ca = 40·07)—*continued.*				
Ca	$CaSO_4$ into	$CaSO_4 \cdot 2H_2O$	1·26467	0·101 98
,,	,, ,,	[illegible]	[illegible]58811	1̄·769 4[illegible]
,,	[illegible] ,,	[illegible]	[illegible]	[illegible]
,,	,, ,,	[illegible]	[illegible]	1̄·877 79
,,	,, ,,	[illegible]	[illegible]	1̄·660 77
,,	,, ,,	P	[illegible]	1̄·301 18
,,	[illegible]	[illegible]	[illegible]	[illegible]
CARBON (C = 12)				
C	CO_2 into	C	0·2727[illegible]	1̄·435 7[illegible]
,,	,, ,,	$CaCO_3$	2·27[illegible]	0·356 [illegible]
,,	,, ,,	Na_2CO_3	2·40[illegible]	0·381 85
,,	,, ,,	$NaHCO_3$	1·90927	0·280 87
,,	,, ,,	$PbCO_3$	6·07045	0·783 22
,,	$2CO_2$,,	MnO_2	0·98784	1̄·994 69
,,	C_2H_6O ,,	$C_2H_4O_2$	1·30368	0·115 17
CHLORINE (Cl = 35·46)				
Cl	Cl into	HCl	1·02843	0·012 47
,,	,, ,,	NaCl	1·64862	0·217 12
,,	,, ,,	KCl	2·10265	0·322 77
,,	Cl_2 ,,	$MgCl_2$	1·34282	0·128 05
,,	,, ,,	$CaCl_2$	1·56500	0·194 52
,,	,, ,,	O	0·22560	1̄·353 35
CHROMIUM (Cr = 52)				
Cr	Cr_2O_3 into	Cr_2	0·68421	1̄·835 19
,,	,, ,,	$K_2Cr_2O_7$	1·93553	0·286 80
COBALT (Co = 58·97)				
Co	CoO into	Co	0·78658	1̄·895 74

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued*

Element	To convert		Into	Factor	Logarithm
	[illegible]				
Cu	Cu	[illegible]	[illegible]	[illegible]	[illegible]
"	[illegible]	.	[illegible]	[illegible]	[illegible]
	[illegible]	.	[illegible]	[illegible]	[illegible]
"	[illegible]		[illegible]	[illegible]	[illegible]
	[illegible]		[illegible]	[illegible]	[illegible]
	[illegible]				
F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			[illegible]	[illegible]	[illegible]
	HYDROGEN. H = [illegible]				
H	HCl	[illegible]	[illegible]	[illegible]	[illegible]
"	HNO₃	.	N	[illegible]	[illegible]
"	"		N₂O₅	[illegible]	[illegible]
"	2HNO₃	.	N₂O₅	[illegible]	[illegible]
	H₂SO₄	.	(NH₄)₂SO₄	[illegible]	[illegible]
	"	"	2HCl	[illegible]	[illegible]
		.	SO₃	[illegible]	[illegible]
"	[illegible] H₂O	"	[illegible]	[illegible]	[illegible]
	IRON. Fe = 55·84				
Fe	Fe	into	FeO	1·2865	0·10942
"	"	"	FeCO₃	2·07450	0·3[illegible]9[illegible]
"	"		FeS₂	2·14830	0·33209
"	"		FeSO₄.7H₂O	4·97890	0·69712
"	Fe₂		Fe₂O₃	1·42980	0·15528
"	"	"	Fe₂O₃.H₂O	1·59112	0·20170
"	"	"	Fe₂O₃.3H₂O	1·91375	0·281[illegible]9

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	IRON (Fe = 55·84)—*continued.*				
Fe	Fe_2	into	$Fe_2(PO_4)_2$	2·70200	0·431 69
„	„	„	MnO_2	0·77838	$\bar{1}$·891 19
„	Fe_2O_3	„	Fe_2	0·69940	$\bar{1}$·844 72
„	„	„	$Fe_2(PO_4)_2$	1·88978	0·276 41
„	$3Fe_2O_3$	„	$2Fe_3O_4$	0·96660	$\bar{1}$·985 25
„	FeS	„	Fe	0·63520	$\bar{1}$·802 91
„	2FeS	„	Fe_2O_3	0·90820	$\bar{1}$·958 18
„	FeS_2	„	S_2	0·53452	$\bar{1}$·727 96
„	$2\{Fe(NH_4)_2(SO_4)_2,6H_2O\}$	into	MnO_2	0·11083	$\bar{1}$·044 68
	LEAD (Pb = 207·2)				
Pb	Pb	into	PbO	1·07724	0·032 30
„	PbS	„	Pb	0·86597	$\bar{1}$·937 50
„	„	„	PbO	0·93281	$\bar{1}$·969 81
„	3PbO	„	$2PbCO_3, Pb(OH)_2$	1·15833	0·063 83
„	PbO_2	„	Pb	0·86622	$\bar{1}$·937 63
„	$PbSO_4$	„	Pb	0·68322	$\bar{1}$·834 56
„	„	„	PbO	0·73597	$\bar{1}$·866 86
„	„	„	PbS	0·78897	$\bar{1}$·897 06
„	$PbCrO_4$	„	Pb	0·64109	$\bar{1}$·806 92
„	„	„	PbO	0·69059	$\bar{1}$·839 22
„	„	„	$PbSO_4$	0·93834	$\bar{1}$·972 36
„	$2PbCrO_4$	„	Cr_2O_3	0·23515	$\bar{1}$·371 34
„	„	„	$K_2Cr_2O_7$	0·45514	$\bar{1}$·658 14
„	$3PbCrO_4$	„	$2PbCO_3, Pb(OH)_2$	0·79993	$\bar{1}$·903 05

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	MAGNESIUM ($Mg = 24·32$)				
Mg	$MgCl_2$	into	MgO	0·4[illegible]	$\bar{1}$·626 70
”	”	”	Cl_2	0·74464	$\bar{1}$·871 95
”	MgO	”	$MgCO_3$	2·09127	0·320 41
”	”	”	$MgCl_2$	2·36210	0·373 30
”	”	”	$MgSO_4$	2·98586	0·475 07
”	”	”	$MgSO_4, 7H_2O$	6·11364	0·786 30
”	”	”	$Mg(NO_3)_2$	3·67907	0·565 74
”	$Mg_2P_2O_7$	”	Mg_2	0·21839	$\bar{1}$·339 23
”	”	”	$2MgO$	*0·36207	$\bar{1}$·558 79
”	”	”	$2MgCO_3$	0·75718	$\bar{1}$·879 20
”	”	”	$2MgCl_2$	0·85524	$\bar{1}$·932 09
”	”	”	$2MgSO_4$	1·08109	0·033 86
”	”	”	$2(MgSO_4, 7H_2O)$	2·21356	0·345 09
”	”	”	P_2	0·27874	$\bar{1}$·445 19
”	”	”	P_2O_5	0·63793	$\bar{1}$·804 77
”	”	”	$2H_3PO_4$	0·88060	$\bar{1}$·944 78
”	”	”	$CaH_4(PO_4)_2$	1·05116	0·021 79
”	”	”	$Ca(PO_3)_2$	0·88968	$\bar{1}$·949 23
”	”	”	$Ca_3(PO_4)_2$	1·39318	0·144 01
”	$MgSO_4$	”	Mg	0·20201	$\bar{1}$·305 37
”	”	”	MgO	0·33491	$\bar{1}$·524 93
	MANGANESE ($Mn = 54·93$)				
Mn	Mn	into	MnO	1·29128	0·111 02
”	MnO	”	Mn	0·77442	$\bar{1}$·888 98
”	MnO_2	”	Mn	0·63189	$\bar{1}$·800 64

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* Or use the Phosphate Table, pp. 130–137, subtracting from the $Mg_2P_2O_7$ found the P_2O_5 in it.

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	MANGANESE (Mn = 54·93)—*contd.*				
Mn	Mn_3O_4	into	3Mn	0·72027	1·857 49
"	"	"	3MnO	0·93007	$\bar{1}$·968 51
"	MnS	"	Mn	0·63138	$\bar{1}$·800 29
"	"	"	MnO	0·81529	$\bar{1}$·911 31
"	$MnSO_4$	"	Mn	0·36377	$\bar{1}$·560 83
"	"	"	MnO	0·46974	$\bar{1}$·671 85
	MERCURY (Hg = 200·6)				
Hg	HgS	into	Hg	0·86217	1·935 59
"	"	"	HgO	0·93093	$\bar{1}$·968 92
"	Hg_2Cl_2	"	2Hg	0·84978	$\bar{1}$·929 31
"	"	"	Hg_2O	0·88367	$\bar{1}$·946 29
	MOLYBDENUM				
Mo	Ammonium phospho-molybdate (dried at 100° C.)	into	P	0·0163	$\bar{2}$·212 19
"	"	"	P_2O_5	0·0373	$\bar{2}$·571 77
"	"	into	$Ca_3(PO_4)_2$	0·08147	$\bar{2}$·911 00
	NICKEL (Ni = 58·68)				
Ni	NiO	into	Ni	0·78575	$\bar{1}$·895 29
	NITROGEN (14·01) AND AMMONIUM (18 042)				
N	N	into	NH_3	1·21585	0·084 88
"	"	"	HNO_3	4·49807	0·653 03
"	"	"	$NaNO_3$	6·06780	0·783 03
"	"	"	KNO_3	7·21700	0·858 36
"	"	"	Albuminoids	6·25	0·795 88
"	"	"	Caffeine	3·46395	0·539 57

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued*.

Element.	To convert			Factor.	Logarithm (to be *added*).
	NITROGEN (14·01) AND AMMONIUM (18·042)—*continued*.				
N	N_2	into	$(NH_4)_2SO_4$	4·71642	0·673 61
,,	,,	,,	N_2O_5	3·85510	0·586 04
,,	N_2O_5	,,	N_2	0·25940	$\bar{1}$·413 96
,,	,,	,,	$2NaNO_3$	1·57397	0·197 00
,,	,,	,,	$2KNO_3$	1·87206	0·272 32
,,	,,	,,	$Ca(NO_3)_2$	1·51907	0·181 58
,,	,,	,,	$Mg(NO_3)_2$	1·37326	0·137 75
,,	NH_3	,,	N	0·82247	$\bar{1}$·915 12
,,	,,	,,	NH_4Cl	3·14090	0·497 05
,,	$2NH_3$	,,	$(NH_4)_2SO_4$	3·87912	0·588 73
,,	NH_4Cl	,,	N	0·26186	$\bar{1}$·418 07
,,	,,	,,	NH_3	0·31838	$\bar{1}$·502 95
,,	$(NH_4)_2SO_4$	,,	N_2	0·21202	$\bar{1}$·326 39
,,	,,	,,	$2NH_3$	0·25779	$\bar{1}$·411 27
,,	,,	,,	H_2SO_4	0·74221	$\bar{1}$·870 53
	PHOSPHORUS (P = 31·01)				
P	P_2	into	P_2O_5	2·28866	0·359 58
,,	P_2O_5	,,	P_2	0·43694	$\bar{1}$·640 42
,,	,,	,,	$Ca_3(PO_4)_2$	2·18391	0·339 23
,,	,,	,,	$CaH_4(PO_4)_2$	1·64824	0·217 02
	PLATINUM (Pt = 195·2)				
Pt	$(NH_4)_2PtCl_6$	into	N_2	0·06310	$\bar{2}$·800 04
,,	,,	,,	$2NH_3$	0·07672	$\bar{2}$·884 92
,,	,,	,,	$2NH_4Cl$	0·24098	$\bar{1}$·381 97
,,	,,	,,	$(NH_4)_2SO_4$	0·29761	$\bar{1}$·473 69

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	PLATINUM (Pt = 195·2)—*contd.*				
Pt	K_2PtCl_6	into	K	0·16085	$\bar{1}$·206 43
"	"	"	2KCl	0·30673	$\bar{1}$·486 76
"	"	"	K_2O	0·19376	$\bar{1}$·287 27
"	"	"	K_2SO_4	0·35846	$\bar{1}$·551 44
"	Pt	"	$2NH_4Cl$	0·54818	$\bar{1}$·738 92
"	"	"	$(NH_4)_2SO_4$	0·67702	$\bar{1}$·830 60
	POTASSIUM (K = 39·1)				
K	K	into	KCl	1·90690	0·280 33
"	K_2	"	K_2O	1·20460	0·080 84
"	KCl	"	Cl	0·47559	$\bar{1}$·677 23
"	"	"	$KHC_4H_4O_6$	2·52320	0·401 95
"	2KCl	"	K_2O	0·63171	$\bar{1}$·800 52
"	"	"	K_2SO_4	1·16866	0·067 69
"	$KClO_4$	"	KCl	0·5381†	$\bar{1}$·730 87
"	$2KClO_4$	"	K_2O	0·3400†	$\bar{1}$·531 44
"	"	"	K_2SO_4	0·62887†	$\bar{1}$·798 56

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* International methods of determining potash were adopted at the International Congress of Applied Chemistry held at Berlin, 1903 (see *Chemical News*, No. 2615.‡ Feb. 4, 1910) The platinochloride pp. is to be dried at 120–130° C., weighed warm, and the following factors (which are based on Berzelius's atomic weight Pt = 197·2) used: –

$K_2PtCl_6 \times 0\cdot30568 = KCl$ (log. $\bar{1}\cdot48515$)

" $\times 0\cdot19305 = K_2O$ (log. $\bar{1}\cdot28567$)

" $\times 0\cdot35714 = K_2SO_4$ (log. $\bar{1}\cdot55284$)

† These are the factors used in connection with the International perchloric acid method for determining potash (see note above).

‡ Also reprinted in pamphlet form.

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	POTASSIUM (K = 39·1)—*contd.*				
K	K_2O	into	2KCl	1·58301	0·199 19
”	”	”	K_2SO_4	1·85000	0·267 17
”	”	”	$2KNO_3$	2·14671	0·331 77
”	”		K_2CO_3	1·46709	0·166 46
”	”	into	$2\{KNaC_4H_4O_6, 4H_2O\}$	5·99138	0·777 53
”	”	into	$2KHC_4H_4O_6$	3·99427	0·601 41
”	”	”	2KOH	1·19125	0·076 00
”	2KOH	”	K_2O	0·83945	$\bar{1}$·924 00
”	K_2CO_3	”	K_2O	0·68162	$\bar{1}$·833 54
”	K_2SO_4	”	K_2O	0·54054	$\bar{1}$·732 83
”	”	”	2KCl	0·85568	$\bar{1}$·932 31
”	KNO_3	”	N	0·13856	$\bar{1}$·141 61
	SILICON (Si = 28·3)				
Si	SiO_2	into	Si	0·46932	$\bar{1}$·671 17
	SILVER (Ag = 107·88)				
Ag	AgBr	into	Br	0·42556	$\bar{1}$·628 96
”	AgCl	”	Ag	0·75262	$\bar{1}$·876 57
”	”	”	Cl	0·24738	$\bar{1}$·393 37
”	”	”	HCl	0·25442	$\bar{1}$·405 54
”	”	”	$AgNO_3$	1·18522	0·073 80
”	AgI	”	I	0·54055	$\bar{1}$·732 83
	SODIUM (Na = 23)				
Na	Na	into	NaCl	2·54174	0·405 13
”	Na_2	”	Na_2O	1·34783	0·129 63
”	Na_2O	”	2NaCl	1·88580	0·275 50

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	SODIUM (Na = 23)—*continued.*				
Na	Na_2O	into	Na_2SO_4	2·29145	0·360 11
"	"	"	Na_2CO_3	1·70968	0·232 91
"	"	"	$2NaNO_3$	2·74226	0·438 11
"	"	"	$2NaOH$	1·29058	0·110 79
"	$Na_2B_4O_7$	"	$Na_2B_4O_7, 10H_2O$	1·89365	0·277 30
"	$NaCl$	"	Cl	0·60657	$\bar{1}$·782 88
"	"	"	$NaHCO_3$	1·43702	0·157 46
"	$2NaCl$	"	Na_2O	0·53028	$\bar{1}$·721 50
"	"	"	Na_2CO_3	0·90660	$\bar{1}$·957 42
"	Na_2CO_3	"	Na_2O	0·58491	$\bar{1}$·767 09
"	$NaNO_3$	"	N	0·16480	$\bar{1}$·216 97
"	$2NaOH$	"	Na_2O	0·77484	$\bar{1}$·889 21
"	Na_2CO_3	"	$Na_2CO_3, 10H_2O$	2·69811	0·431 06
"	Na_2SO_4	"	Na_2	0·32378	$\bar{1}$·510 26
"	"	"	Na_2O	0·43640	$\bar{1}$·639 89
	STRONTIUM (Sr = 87·63)				
Sr	$SrCO_3$	into	Sr	0·59358	$\bar{1}$·773 48
"	$SrSO_4$	"	Sr	0·47703	$\bar{1}$·678 54
	SULPHUR (S = 32·06)				
S	SO_3	into	S	0·40045	$\bar{1}$·602 55
"	"	"	$CaSO_4$	1·70036	0·230 54
"	"	"	$CaSO_4, 2H_2O$	2·15040	0·332 52
"	"	"	H_2SO_4	1·22500	0·088 15
"	"	"	$(NH_4)_2SO_4$	1·65056	0·217 63

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor	Logarithm (to be *added*).
	SULPHUR ($S = 32·06$)—*continued.*				
S	SO_3	into	K_2SO_4	2·17660	0·337 78
,,	,,	,,	Na_2SO_4	1·77410	0·249 06
,,	,,	,,	$MgSO_4$	1·50360	0·177 14
	TIN ($Sn = 118·7$)				
Sn	Sn	into	SnO_2	1·26960	0·103 66
,,	SnO_2	,,	Sn	0·78766	$\bar{1}$·896 34
	ZINC ($Zn = 65·37$)				
Zn	Zn	into	ZnO	1·24176	0·095 09
,,	,,	,,	ZnS	1·19059	0·173 36
,,	,,	,,	$ZnCl_2$	2·08490	0·319 09
,,	ZnO	,,	Zn	0·80337	$\bar{1}$·904 91
,,	ZnS	,,	Zn	0·67087	$\bar{1}$·826 64

Example.—1·327 grams of a substance gave 0·8470 gram $BaSO_4$: to find the percentages of SO_3 and S present respectively.

Since 1·327 grams give 0·847 gram $BaSO_4$, 100 grams will give

$$\frac{·847 \times 100}{1·327} = \frac{84·70}{1·327}$$

Taking logs. Log. 84·70 = 1·92788
,, 1·327 = 0·12287

(subtracting) 1·80501
Add log. ($BaSO_4$ into SO_3) $\bar{1}$·53529

1·34030 = 21·89 per cent. SO_3.
Add log. (SO_3 into S) $\bar{1}$·60263

0·91293 = 8·77 per cent. S.

Rule.—First find the weight of the pp. that 100 parts of substance would give, then add the log. of the factor to get percentage of substance sought.

Element.	To convert	Factor.	Logarithm (to be *added*).

VOLUMETRIC FACTORS.

Definition.—A **Normal Solution** of a reagent is one that contains in a litre that proportion of its molecular weight in grams which corresponds to 1·008 grams of available hydrogen or its equivalent.

Thus, a normal solution of hydrochloric acid contains 36·468 grams HCl per litre; and normal sulphuric acid $\frac{98·076}{2} = 49·038$ grams H_2SO_4 per litre. Potassium permanganate, $K_2Mn_2O_8$, in acid solution, yields 5 atoms of oxygen, equivalent to 10 atoms of hydrogen; hence a normal solution of permanganate contains $\frac{316·06}{10} = 31·606$ grams per litre. Normal alkali solutions are such that a given volume requires for neutralization an equal volume of a normal acid solution.

		grams		Logarithms
Normal H_2SO_4	1 c.c.	= 0·049038	H_2SO_4 . . .	$\bar{2}$·690 53
	,,	0·048030	SO_4 . . .	$\bar{2}$·681 51
	,,	0·040030	SO_3 . . .	$\bar{2}$·602 39
Normal HCl	1 c.c.	0·036468	HCl . . .	$\bar{2}$·561 91
	,,	0·03546	Cl . .	$\bar{2}$·549 74
Normal HNO_3	1 c.c.	= 0·063018	HNO_3 . .	$\bar{2}$·799 46
	,,	= 0·06201	NO_3 . . .	$\bar{2}$·792 46
	,,	= 0·05401	N_2O_5 . .	$\bar{2}$·732 47
Normal $H_2C_2O_4$	1 c.c.	= 0·063024	$H_2C_2O_4$, $2H_2O$.	$\bar{2}$·799 51
	,,	= 0·045008	$H_2C_2O_4$ . .	$\bar{2}$·653 29
Normal acid	1 c.c.	= 0·01401	N . . .	$\bar{2}$·146 44
	,,	= 0·017034	NH_3 . . .	$\bar{2}$·231 32
	,,	= 0·03505	NH_4OH . .	$\bar{2}$·544 69
	,,	= 0·1008	$Na_2B_4O_7$ . . .	$\bar{1}$·003 46
	,,	= 0·19088	$Na_2B_4O_7$, $10H_2O$	$\bar{1}$·280 76

VOLUMETRIC FACTORS—*continued.*

		grams.		Logarithms.
Normal acid (*continued*).	1 c.c.	= 0·028035	CaO	$\bar{2}$·147 70
	„	= 0·037043	$Ca(OH)_2$	$\bar{2}$·568 71
	„	= 0·050035	$CaCO_3$	$\bar{2}$·699 27
	„	= 0·085693	$Ba(OH)_2$	$\bar{2}$·932 95
	„	= 0·157757	$Ba(OH)_2, 8H_2O$	$\bar{1}$·197 99
	„	= 0·098685	$BaCO_3$	$\bar{2}$·994 25
	„	= 0·02016	MgO	$\bar{2}$·304 49
	„	= 0·04216	$MgCO_3$	$\bar{2}$·624 90
	„	= 0·056108	KOH	$\bar{2}$·749 02
	„	= 0·0691	K_2CO_3	$\bar{2}$·839 48
	„	= 0·18811	$KHC_4H_4O_6$	$\bar{1}$·274 48
	„	= 0·108119	$K_3C_6H_5O_7, H_2O$	$\bar{1}$·033 90
	„	= 0·098124	$KC_2H_3O_2$	$\bar{2}$·991 78
	„	= 0·141098	$KNaC_4H_4O_6, 4H_2O$	$\bar{1}$·149 52
	„	= 0·040008	$NaOH$	$\bar{2}$·602 15
	„	= 0·053	Na_2CO_3	$\bar{2}$·724 28
	„	= 0·14308	$Na_2CO_3, 10H_2O$	$\bar{1}$·155 58
	„	= 0·084008	$NaHCO_3$	$\bar{2}$·924 32
Normal KOH	1 c.c.	= 0·056108	KOH	$\bar{2}$·749 02
	„	= 0·0471	K_2O	$\bar{2}$·673 02
Normal NaOH	1 c.c.	= 0·040008	$NaOH$	$\bar{2}$·602 15
	„	= 0·031	Na_2O	$\bar{2}$·491 36
Normal Na_2CO_3	1 c.c.	= 0·053	Na_2CO_3	$\bar{2}$·724 28
	„	= 0·030	CO_3	$\bar{2}$·477 12
	„	= 0·022	CO_2	$\bar{2}$·342 42
Normal alkali	1 c.c.	= 0·060032	$HC_2H_3O_2$	$\bar{2}$·778 38
	„	= 0·0349	B_2O_3	$\bar{2}$·542 83
	„	= 0·061924	H_3BO_3	$\bar{2}$·791 86
	„	= 0·0504	$Na_2B_4O_7$	$\bar{2}$·702 43
	„	= 0·09511	$Na_2B_4O_7, 10H_2O$	$\bar{2}$·979 73

VOLUMETRIC FACTORS—*continued.*

		grams.		Logarithms.
Normal alkali (*continued*).	1 c.c. =	0·070027	$H_3C_6H_5O_7, H_2O$.	$\bar{2}$·845 27
	,, =	0·122048	benzoic acid	$\bar{1}$·086 53
	,, =	0·088064	butyric ,, .	$\bar{2}$·944 80
	,, =	0·410432	cerotic ,, . .	$\bar{1}$·613 21
	,, =	0·090048	lactic ,, .	$\bar{2}$·954 47
	,, =	0·067024	malic ,, . .	$\bar{2}$·826 23
	,, =	0·282272	oleic ,, .	$\bar{1}$·450 67
	,, =	0·256256	palmitic ,, .	$\bar{1}$·408 67
	,, =	0·284288	stearic ,, .	$\bar{1}$·453 76
	,, =	0·075024	tartaric ,, . .	$\bar{2}$·875 20
	,, =	0·18814	$KHC_4H_4O_6$.	$\bar{1}$·274 48
$\frac{N}{10}$ $AgNO_3$	1 c.c. =	0·010788	Ag . . .	$\bar{2}$·032 94
	,, =	0·016989	$AgNO_3$ . .	$\bar{2}$·230 17
	,, =	0·003546	Cl . .	$\bar{3}$·549 74
	,, =	0·005846	NaCl .	$\bar{3}$·766 86
	,, =	0·0053502	NH_4Cl .	$\bar{3}$·728 37
	,, =	0·011902	KBr . .	$\bar{2}$·075 62
	,, =	0·007456	KCl . .	$\bar{3}$·872 51
	,, =	0·016602	KI . .	$\bar{2}$·220 16
	,, =	0·010292	NaBr . .	$\bar{2}$·012 50
	,, =	0·006199	Na_2HAsO_4 . .	$\bar{3}$·792 32
$\frac{N}{10}$ Iodine	1 c.c =	0·003203	SO_2 . . .	$\bar{3}$·505 56
	,, =	0·0041038	H_2SO_3 . .	$\bar{3}$·613 19
	,, =	0·0126086	$Na_2SO_3, 7H_2O$.	$\bar{2}$·100 67
	,, =	0·0097146	$K_2SO_3, 2H_2O$.	$\bar{3}$·987 42
	,, =	0·02482	$Na_2S_2O_3, 5H_2O$.	$\bar{2}$·391 80
	,, =	0·004948	As_4O_6 . .	$\bar{3}$·694 13
$\frac{N}{10}$ Dichromate	1 c.c. =	0·005584	Fe . .	$\bar{3}$·746 9[illegible]
	,, =	0·007184	FeO . . .	$\bar{3}$·856 37
	,, =	0·011584	$FeCO_3$ . .	$\bar{2}$·063 86
	,, =	0·01519	$FeSO_4$ . . .	$\bar{2}$·181 56
	,, =	0·0278012	$FeSO_4, 7H_2O$.	[illegible]·444 06

VOLUMETRIC FACTORS—*continued.*

grams.	Logarithms.
$\frac{N}{10}$ Thiosulphate 1 c.c. = 0·02482 $Na_2S_2O_3, 5H_2O$.	$\bar{2}$·394 80
,, = 0·012692 I . .	$\bar{2}$·103 53
,, = 0·003546 Cl . . .	$\bar{3}$·549 71
,, = 0·007992 Br . .	$\bar{3}$·902 66
CALCIUM (Ca = 40·07)	
1 c.c. $\frac{N}{10}$ permanganate = 0·0028035 gram CaO .	$\bar{3}$·447 70
,, ,, = 0·0050035 gram $CaCO_3$.	$\bar{3}$·699 27
,, ,, = 0·0086081 gram $CaSO_4$, $2H_2O$	$\bar{3}$·934 91
,, normal oxalic acid = 0·028035 gram CaO	$\bar{2}$·447 70
Cryst. oxalic acid × 0·444 = CaO . . .	$\bar{1}$·647 38
Ferrous ammonium sulphate × 0·07143 = CaO .	$\bar{2}$·853 88
CHLORINE (Cl = 35·46)	
1 c.c. $\frac{N}{10}$ silver solution = 0·003546 gram Cl .	$\bar{3}$·549 74
,, ,, = 0·005846 gram NaCl .	$\bar{3}$·766 86
1 c.c. $\frac{N}{10}$ arsenious or thiosulphate solution = 0·003546 gram Cl . . .	$\bar{3}$·549 74
CHROMIUM (Cr = 52)	
Metallic iron × 0·3104 = Cr . . .	$\bar{1}$·491 94
,, × 0·5968 = CrO_3 .	$\bar{1}$·775 86
,, × 0·8780 = $K_2Cr_2O_7$ . . .	$\bar{1}$·943 47
,, × 1·929 = $PbCrO_4$ . . .	0·285 40
Ferrous ammonium sulphate × 0·0443 = Cr . .	$\bar{2}$·646 40
,, × 0·0853 = CrO_3 .	$\bar{2}$·930 95
,, × 0·1253 = $K_2Cr_2O_7$.	$\bar{1}$·097 95
,, × 0·2747 = $PbCrO_4$.	$\bar{1}$·438 91
1 c.c. $\frac{N}{10}$ solution = 0·003333 gram CrO_3 . .	$\bar{3}$·522 84
,, ,, = 0·004903 gram $K_2Cr_2O_7$ . .	$\bar{3}$·690 45

VOLUMETRIC FACTORS—*continued.*

	Logarithms.
COPPER ($Cu = 63·57$)	
1 c.c. $\frac{N}{10}$ solution = 0·006357 gram Cu . .	$\bar{3}$·803 25
Iron × 1·138 = copper	0·056 14
Ferrous ammonium sulphate × 0·1622 = copper .	$\bar{1}$·210 05
CYANOGEN ($CN = 26·01$)	
1 c.c. $\frac{N}{10}$ silver solution = 0·005202 gram CN .	$\bar{3}$·716 17
,, ,, = 0·005401 gram HCN	$\bar{3}$·732 72
,, ,, = 0·013022 gram KCN .	$\bar{2}$·114 68
,, $\frac{N}{10}$ iodine = 0·003255 gram KCN .	$\bar{3}$·512 55
POTASSIUM FERROCYANIDE ($K_4FeCy_6, 3OH_2 = 422·348$)	
Metallic iron × 7·563 = cryst. potassium ferrocyanide	0·878 69
Ferrous ammonium sulphate × 1·080 = cryst. potassium ferrocyanide . .	0·033 12
POTASSIUM FERRICYANIDE ($K_6Fe_2Cy_{12} = 658·4$)	
Metallic iron × 5·895 = potassium ferricyanide .	0·770 48
Ferrous ammonium sulphate × 1·684 = potassium ferricyanide . .	0·226 34
$\frac{N}{10}$ thiosulphate × 0·03292 = potassium ferricyanide	$\bar{2}$·517 46
GOLD ($Au = 197·2$)	
1 c.c. normal oxalic acid = 0·0657 gram gold .	$\bar{2}$·817 57
IODINE ($I = 126·92$)	
1 c.c. $\frac{N}{10}$ thiosulphate = 0·012692 gram iodine	$\bar{2}$·103 53
IRON ($Fe = 55·84$)	
1 c.c. $\frac{N}{10}$ permanganate, dichromate, or thiosulphate = 0·005584 Fe	$\bar{3}$·746 95
,, ,, = 0·007184 FeO .	$\bar{3}$·856 37
,, ,, = 0·007984 Fe_2O_3	$\bar{3}$·902 22

VOLUMETRIC FACTORS—*continued.*

	Logarithms.
LEAD (Pb = 207·2)	
1 c.c. $\frac{N}{10}$ permanganate = 0·01036 gram lead	$\bar{2}$·015 36
1 c.c. normal oxalic acid = 0·1036 gram lead	$\bar{1}$·015 36
Metallic iron × 1·855 lead	0·268 41
Ferrous ammonium sulphate × 0·261 = lead	$\bar{1}$·421 92
MANGANESE (Mn = 54·93)	
MnO = 70·93. MnO_2 = 86·93.	
Metallic iron × 0·4918 Mn	$\bar{1}$·691 79
,, × 0·6350 MnO	$\bar{1}$·802 77
,, × 0·7783 = MnO_2	$\bar{1}$·891 15
Ferrous ammonium sulphate × 0·0907 MnO	$\bar{2}$·957 61
,, × 0·1112 = MnO_2	$\bar{1}$·046 10
Cryst. oxalic acid × 0·6896 MnO_2	$\bar{1}$·838 60
1 c.c. $\frac{N}{10}$ solution = 0·003547 gram MnO	$\bar{3}$·549 86
,, ,, = 0·004347 gram MnO_2	$\bar{3}$·638 19
MERCURY (Hg = 200·6)	
Ferrous ammonium sulphate × 0·5115 = Hg	$\bar{1}$·708 86
,, × 0·6924 $HgCl_2$	$\bar{1}$·840 33
1 c.c. $\frac{N}{10}$ solution = 0·02006 gram Hg	$\bar{2}$·302 33
,, ,, = 0·02086 gram Hg_2O	$\bar{2}$·319 31
,, ,, = 0·027152 gram $HgCl_2$	$\bar{2}$·433 80
NITROGEN AS NITRATES AND NITRITES	
N_2O_5 = 108·02 N_2O_3 = 76·02	
Normal acid × 0·0540 = N_2O_5	$\bar{2}$·732 39
,, × 0·1011 = KNO_3	$\bar{1}$·004 75
Metallic iron × 0·3761 = HNO_3	$\bar{1}$·575 30
,, × 0·6035 = KNO_3	$\bar{1}$·780 68
,, × 0·3224 = N_2O_5	$\bar{1}$·508 40
SILVER (Ag = 107·88)	
1 c.c. $\frac{N}{10}$ NaCl = 0·010788 gram Ag	$\bar{2}$·032 94
,, = 0·016989 ,, $AgNO_3$	$\bar{2}$·230 17

VOLUMETRIC FACTORS—*continued.*

		Logarithms.
SULPHURETTED HYDROGEN ($H_2S = 34·076$)		
1 c.c. $\frac{N}{10}$ arsenious solution = 0·002556 gram H_2S		$\bar{3}$·407 51
TIN ($Sn = 118·7$)		
Metallic iron	× 1·063 = tin	0·026 48
Ferrous ammonium sulph.	× 0·1514 = tin	$\bar{1}$·179 98
Factor for $\frac{N}{10}$ iodine or permanganate solution, 0·005935		$\bar{3}$·773 42
ZINC ($Zn = 65·37$)		
Metallic iron	× 0·5852 = Zn	$\bar{1}$·767 33
,,	× 0·7285 = ZnO	$\bar{1}$·862 41
Ferrous ammonium sulphate	× 0·0836 = Zn	$\bar{2}$·922 21
,,	× 0·1041 = ZnO	$\bar{1}$·017 45
1 c.c. $\frac{N}{10}$ solution = 0·003268 gram Zn		$\bar{3}$·514 28

NITROMETER ANALYSIS.

1 c.c. NO at N.T.P.	= 0·6257	mgm.	N	$\bar{1}$·796 34
,, ,,	1·3402	,,	NO	0·127 17
,, ,,	1·6975	,,	N_2O_3	0·229 81
,, ,,	2·4121	,,	N_2O_5	0·382 40
,, ,,	2·8141	,,	HNO_3	0·449 39
,, ,,	= 3·8009	,,	KNO_2	0·579 88
,, ,,	= 4·5151	,,	KNO_3	0·654 70
,, ,,	= 3·0819	,,	$NaNO_2$	0·488 82
,, ,,	= 3·7986	,,	$NaNO_3$	0·579 62
,, ,,	= 5·2294	,,	$C_5H_{11}NO_2$	0·718 45
,, ,,	= 3·3516	,,	$C_2H_5NO_2$	0·525 25
,, at 15·6° C. and 760 mm.	= 3·170	,,	,,	0·500 89

Temperature ° C.	For use in Calibrating Instruments.		For use with Standard Solutions.	
	Weight of 1 Litre of Water	Volume of 1 Gram of Water.	Volume corresponding with 1 Litre at 15° C.	Volume of 1 c.c. reduced to 15° C.
	grams.	c.c.	c.c.	c.c.
5	998·6	1·0014	998·3	1·0017
6	,,	,,	·4	1·0016
7	,,	,,	·5	1·0014
8	,,	,,	·7	1·0013
9	,,	,,	·9	1·0011
10	998·5	1·0015	999·0	1·0010
11	,,	,,	·2	1·0008
12	998·1	1·0016	·4	1·0006
13	·3	1·0017	·6	1·0004
14	·2	1·0018	·8	1·0002
15	·1	1·0019	1000·0	1·0000
16	997·9	1·0021	·2	0·9998
17	·8	1·0022	·4	0·9996
18	·7	1·0023	·6	0·9994
19	·5	1·0025	·8	0·9992
20	·3	1·0027	1001·1	0·9989
21	·2	1·0028	·3	0·9987
22	997·0	1·0030	·6	0·9984
23	996·8	1·0032	·8	0·9982
24	·6	1·0034	1002·0	0·9980
25	·3	1·0037	·3	0·9977

Coefficients of Absorption of Gases in Water.

Gas.	1 volume of Water dissolves at 760 mm Pressure.					Observer.
	0° C.	4° C.	10° C.	15° C.	20° C.	
Acetylene, . . .	1·73	1·53	1·31	1·15	1·03	Winkler
Air *, ...	0·02882	0·02606	0·02265	0·02046	0·01870	,,
Ammonia, . .	1158·08	1048·23	898·67	770·29†	696·17	Roscoe and Dittmar
Carbon monoxide,	0·03537	0·03219	0·02816	0·02543	0·02319	Winkler
,, dioxide, .	1·713	1·473	1·194	1·019	0·878	Bohr and Bock
Chlorine, . .	3·0362		2·5852	2·3681	2·1565	Schönfeld
Hydrogen, . .	0·02148	0·02064	0·01955	0·01883	0·01819	Winkler
,, sulphide,	4·3706	4·0442	3·5858	3·2326	2·9053	Schönfeld
Methane, . .	0·05473	0·05002	0·04366	0·03902	0·03498	Hinrichs
Nitric oxide, .	0·07381	0·06628	0·05709	0·05147	0·04706	Winkler
Nitrous ,, . .	1·3052	1·1346	0·9196	0·7778	0·6700	Carius
Nitrogen, . .	0·02348	0·02130	0·01857	0·01682	0·01542	Winkler
Oxygen, .	0·04890	0·04397	0·03802	0·03415	0·03102	,,
Sulphur dioxide, .	79·789	69·828	56·647	47·276	39·374	Schönfeld

* Calculated from nitrogen and oxygen. † At 16° C.

*** Hydrogen chloride—506 vols. at 0° C., 474 at 10°, 458 at 15°, and 442 at 20°.

Table of Reciprocals.

No.	Reciprocal.	No.	Reciprocal.	No.	Reciprocal.	No.	Reciprocal.
1	1	31	·03226	61	·01639	91	·01099
2	·5	32	·03125	62	·01613	92	·01087
3	·33333	33	·03030	63	·01587	93	·01075
4	·25	34	·02941	64	·01563	94	·01064
5	·2	35	·02857	65	·01539	95	·01053
6	·16667	36	·02778	66	·01515	96	·01042
7	·14286	37	·02703	67	·01493	97	·01031
8	·125	38	·02632	68	·01471	98	·01020
9	·11111	39	·02564	69	·01449	99	·01010
10	·1	40	·025	70	·01429	100	·01
11	·09091	41	·02439	71	·01409	101	·00990
12	·08333	42	·02381	72	·01389	102	·00980
13	·07692	43	·02326	73	·01370	103	·00971
14	·07143	44	·02273	74	·01351	104	·00962
15	·06667	45	·02222	75	·01333	105	·00952
16	·0625	46	·02174	76	·01316	106	·00943
17	·05882	47	·02128	77	·01299	107	·00935
18	·05556	48	·02083	78	·01282	108	·00926
19	·05263	49	·02041	79	·01266	109	·00917
20	·05	50	·02	80	·0125	110	·00909
21	·04762	51	·01961	81	·01235	111	·00901
22	·04545	52	·01923	82	·01220	112	·00893
23	·04348	53	·01887	83	·01205	113	·00885
24	·04167	54	·01852	84	·01191	114	·00877
25	·04	55	·01818	85	·01177	115	·00870
26	·03846	56	·01786	86	·01163	116	·00862
27	·03704	57	·01754	87	·01149	117	·00855
28	·03571	58	·01724	88	·01136	118	·00847
29	·03448	59	·01695	89	·01124	119	·00840
30	·03333	60	·01667	90	·01111	120	·00833

Ex. 1. $\frac{100}{17} \times ·01 = \frac{1}{17} = 0·05882.$

Ex. 2. $\frac{100}{43} \times ·02 = \frac{1}{43} \times 2 = ·02326 \times 2 = 0·04652.$

Ex. 3. $\frac{100}{82} \times ·005 = \frac{1}{82} \times \frac{1}{2} = \frac{0·0122}{2} = 0·0061.$

VARIOUS USEFUL FACTORS.

To convert :—	Multiplier	Logarithm
Grains per litre into grains per cubic foot	437·00	2·640 4754
,, ,, ounces (av.) ,,	0·99884	$\bar{1}$·999 4973
,, ,, lb. ,,	0·06243	$\bar{2}$·795 3773
,, ,, grains per fluid oz.	0·43847	$\bar{1}$ 641 9391
,, ,, grains per gallon	70	1·845 0980
Grains per gallon into cwts. per million gallons	1·2755	0·105 6839
,, ,, grains per litre*	0·014286	2·154 9020
Percentage into grains per fluid oz.	4·375	0·610 9781
Percentage into grains per lb.	70	1·845 0980
Litres into cubic feet	0·035321	$\bar{2}$·548 0345
Cubic inches into gallons	0·003604	$\bar{3}$·556 7949
,, feet ,, ,,	6·2279	0·794 3386
,, yards ,,	168·152	2·225 7026

15·68 grains per gallon = 1 ton per million gallons.

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* Or divide by 70.

USEFUL DATA.

I. *Areas and Volumes of Bodies.*

			Logarithms.
Area of a circle	$=\pi r^2$	r = radius	
		$\pi = 3{\cdot}1415926$	0·497 1499
Volume of a sphere	$=\frac{4}{3}\pi r^3$	$\frac{4}{3}\pi = 4{\cdot}1888$	0·622 0886
Volume of a cylinder	$=\pi r^2 h$	r = radius of base h = height	
Surface of sphere	$=4\pi r^2$	$4\pi = 12{\cdot}5664$	1·099 2099

II. *Specific Gravity.*

To convert :—

(1) Degrees of Twaddell's hydrometer into sp. gr. (water = 1000)—multiply by 5 and add 1000

(2) Sp. gr. (water = 1000) into degrees of Twaddell's hydrometer—subtract 1000 and divide by 5

(3) The sp. gr. of gases referred to atmospheric air as unity $= \frac{34{\cdot}52 \times \text{mol. wt.}}{1000} = \frac{\text{mol. wt.}}{28{\cdot}97}$

	Logarithms
1 kilogrammetre = 7·2330 foot-pounds,	0·859 3196
1 foot-pound = 0·13825 kilogrammetres,	$\bar{1}$·140 6804

NOTES ON LOGARITHMS.

Definition.—The logarithm of a number N is the value of x which satisfies the equation $a^x = N$, where a is some given number.

Thus if a be 10 (which is the *base* of Briggs' or the ordinary logarithms), the logarithm of 100 is 2, that of 1000 is 3, and that of any number between 100 and 1000 will be greater than 2 and less than 3, so that it may be represented by 2 followed by places of decimals.

By means of a table of logarithms two numbers may be *multiplied* together by *adding* their logarithms and *divided* by *subtracting* their logarithms, the result in each case being the number corresponding to the logarithm thus obtained. Also Involution, or raising of powers, is performed by multiplication of the logarithm of the number by the index of the power; and Evolution, or extraction of roots, by division of the logarithm of the number by the index of the root.

The integral part of a logarithm is called the *characteristic*, the decimal part the *mantissa*. The characteristic may be either positive or negative (*e.g.*, 2, $\bar{2}$),* but the mantissa is *always positive*. The mantissæ *only* are registered in the tables, the characteristics always being found by the following simple rules:—

(1) For numbers greater than unity, the characteristic is *one less* than the number of digits and is *positive*.

(2) For numbers less than unity, the characteristic is *one greater* than the number of ciphers which precede the first significant figure, and is *negative*.*

Ex. Log. 437·58 = 2·6410575
Log. 43·758 = 1·6410575
Log. 4·3758 = 0·6410575
Log. ·43758 = $\bar{1}$·6410575
Log. ·043758 = $\bar{2}$·6410575

Negative characteristics are calculated according to the ordinary rules of algebraic addition and subtraction. A few examples will show the methods employed.

(1) Addition—

Add 5·3468541
$\bar{3}$·2685427
2·6153968

+5 added to $\bar{3}$ gives +2.

Add 6·3874651
$\bar{2}$·9245639
5·3120290

+6 is increased to +7 by the 1 carried over from the mantissæ, and +7 added to $\bar{2}$ gives +5.

---

*The negative sign is placed *over* the characteristic to indicate that *it alone* is negative. If placed in front, like an ordinary negative sign, both characteristic and mantissa would become negative.

NOTES ON LOGARITHMS—*continued.*

(1) Addition—*continued.*

Add $\bar{2}$·5632874
$\bar{3}$·2465281

$\bar{5}$·8098155

Add $\bar{3}$·3010300
$\bar{2}$·9020029

$\bar{4}$·2030329

Here the + 1 carried over from the mantissæ is added to $\bar{3}$ giving $\bar{2}$, and $\bar{2}$ added to $\bar{2}$ gives $\bar{4}$.

(2) Subtraction.—

Rule.—Change the sign of the characteristic in the lower line, and add as above.

From 2·6847658
Subtract $\bar{3}$·2468543

5·4379115

$\bar{3}$ becomes, on changing its sign, +3, and this added to +2 gives +5.

From $\bar{2}$·3468537
Subtract $\bar{5}$·7654626

2·5813911

Here 1 is carried over from the mantissæ, and has to be subtracted from $\bar{2}$, giving $\bar{3}$; then changing the $\bar{5}$ into + 5, and adding this to $\bar{3}$, we have + 2.

From $\bar{5}$·6843252
Subtract 3·7856310

$\bar{3}$·8986942

Here the 1 carried over subtracted from $\bar{5}$ gives $\bar{6}$; then changing 3 into +3 and adding it to $\bar{6}$ we have $\bar{3}$.

Proportional Parts.—When the logarithm of a number consisting of five figures or less is required, it can be found immediately in the tables; but if the numbers consist of more than five figures, a little calculation is required in order to find its correct logarithm. This calculation is greatly facilitated by the use of a *table of proportional parts.* It will be seen, on reference to the tables, that the differences between the logarithms of numbers differing by 1 in the fifth figure remain remarkably constant for a great many successive numbers, except at the beginning of the tables, where the changes are rather rapid. Thus, from 66500 to 67500 the difference between any two consecutive logarithms is uniformly 65: *e.g.*, log. 66511 (=4·8228935) subtracted from log. 66512 (=4·8229000) gives 65. Suppose, then, we require the logarithm of a number consisting of six or seven figures, as for instance 66511·37, how do we proceed to find it?

NOTES ON LOGARITHMS—*continued.*

This is done as follows:—First write down the next lower logarithm.

Log. 66511 = 4·8228935,

then, since the difference of 1 in the fifth figure makes a difference of 65 in the logarithm, a difference of ·37 will make a difference of 65 × ·37 = 24.

∴ Log. 66511·37 = 4·8228935 + 24 = 4·8228959.

In the *table of proportional parts*, however, the amount to be added for every tenth of a unit is recorded, and by this table the above result may be easily found thus:

Log. 66511	= 4·8228935
Proportional part for ·3 =	20
Proportional part for ·07 =	46
	4·82289596

Conversely, the number to six, seven, or more figures corresponding to a given logarithm, is found by a method exactly the converse of that given above.

Example.—Find the number whose log. is 2·9324547.

2·9324547
2·9324535 = log. 865·96

12
10 = ·002

20 = ·0004

855·9624 the number required.

In the above example the difference between the given log. and the next lower in the tables being 12, the required number will evidently lie between 855·962 and 855·963, since the proportional part for 2 is 10 and that for 3 is 15. Subtracting that for 2, namely 10, we have 2 left. Annex a cipher to the 2, since the figure to be found will occupy the next decimal place, and the number 20 thus obtained is the proportional part for the figure 4.

COMPUTATION.

The following examples will show some of the methods that may be used with great advantage for reducing labour in working out the results of analytical and other chemical work :—

Ex. 1. Multiply 237·2 by 0·9889

$$\cdot 9889 = 1 - \cdot 0111$$

Hence 237·2

less the sum of
2·372
·2372
·02372

234·56708

Ex. 2. Multiply 578·643 by 2·987

$$2\cdot 987 = 3 - \cdot 013$$

578·643
3

1735·929

less the sum of
5·78643
1·735929

1728·406641.

Ex. 3. Multiply 182·76 by 5

$$= 182\cdot 76 \times \frac{10}{2} = \frac{1827\cdot 6}{2} = 913\cdot 8.$$

Ex. 4. Multiply 32·8 by 15.

= 32·8 × 10 = 328
+ half of 32·8 × 10 = 164

492

Ex. 5. Multiply 0·07964 by 25

$$= \cdot 07964 \times \frac{100}{4} = \frac{7\cdot 964}{4} = 1\cdot 991.$$

Similarly to multiply by 2½ use the fraction

Ex. 6. 247·68 × 125 = 247·68 × $\frac{1000}{8}$ = $\frac{247680}{8}$

= 30960.

Similarly to multiply by 12·5 use $\frac{100}{8}$,
and to multiply by ·125, simply divide by 8.

Ex. 7. In like manner, to *divide* by 25,

e.g. $\frac{5768}{25}$. This equals $\frac{5768 \times 4}{100}$ = 57·68 × 4

= 230·72.

APPROXIMATIONS

In many cases the results of chemical investigations may be regarded as accurate to the second or third decimal place only: hence it is simply misleading (not to say deceptive) to calculate such results to the fourth or fifth place of decimals. In these cases the following methods of obtaining *approximate* results, correct to the first or second place of decimals, will be found invaluable.

Rule for multiplication.—Write the multiplier *backwards* under the multiplicand, and multiply in the usual way, each digit of the multiplier being multiplied into the figure immediately above it, those to the right being ignored, *except* that next to it, from which we get the amount to carry forward.

The amount to be carried forward is taken as the nearest multiple of ten. Thus

any number from 1 to 4 counts zero
„ „ 5 to 10 „ 1
„ „ 10 to 14 „ 1
„ „ 15 to 20 „ 2 and so on.

Omit all decimal points at first, the position of the decimal point in the answer being fixed afterwards,* as shown in the examples below.

Ex. 8. Multiply 47·26 by 12·43, giving four figures in the answer.

4726
3421
———
4726
945
189
14
———
5874

In the second line 2 × 6 = 12
∴ carry 1
„ third line 4 × 2 = 8
∴ carry 1
„ fourth line 3 × 7 = 21
∴ carry 2

---

* "When I calculate I seldom trouble my head about the position of the decimal point in my answer until everything else is finished. There are many cleverly contrived rules about the position of the decimal point, but we forget them in practical work. Better never learn them."—Prof. John Perry, F.R.S.

To find where to put the decimal point, we notice that as 47 is nearly 50, the result will be rather less than 50 × 12 = 600. Hence the answer is obviously 587·4.

If greater accuracy had been required, we should have proceeded thus:—

47260
3421

47260
9452
1890
142

58744 Result 587·44.

Ex. 9. Multiply 3·72 by ·0005962.

Here we make 3·72 the multiplier as it shortens the work.

5962
273

17886
4173
119

22178

As 3·72 is nearly 4, the answer will be rather less than ·0006 × 4 = ·0024.

Hence the result is ·0022178, or ·00222 correct to the fifth decimal place.

Ex. 10. To find the number of feet in 726·422 metres, given that 1 metre = 3·2808 feet,

726422
80823

2179266
145284
58114
581

2383245

726 × 3 = 2178, hence the answer is clearly 2383·245.

Rule for division.—Proceed as in the ordinary way, but instead of adding zeros to the dividend cut off digits from the divisor, carrying forward a figure from the digit rejected, just as in multiplication.

Ex. 11. Divide 2·71828 by 3·1416.

```
3,1,4,1,6)271828 (86525
          251328
          ------
           20500
           18850
           -----
            1650
            1571
            ----
              79
              63
              --
              16
              15
              --
               1
```

Since $\frac{2\cdot7}{3} = 0\cdot9$, the answer is evidently 0·86525.

Ex. 12. How many cubic feet would be occupied by 1897·6 gallons of water? (6·228 gallons occupy 1 cubic foot.)

```
6,2,2,8)18976 (304·7
        18684
        -----
          292
          249
          ---
           43
           42
           --
            1
```

Note that as 292 is not divisible by 622, we put zero in the quotient and then divide by 62. The result is 304·7.

Ex. 13. How many litres correspond to 6279864 cubic inches (1 litre = 61·035 cubic inches.)

```
6,1,0,3,5)6279864 (102889·6
          61035
          ------
           176364
           122070
           ------
            54294
            48828
            -----
             5466
             4882
             ----
              584
              549
              ---
               35
               36
```

Here, and in similar cases, proceed exactly as in ordinary division until all the figures in the dividend have been brought down, *then* begin to abbreviate. The result is seen at once to be 102889·6.

Examples requiring the use of Logarithms.

Ex. 14. To find a factor to multiply the number of c.c. of normal sulphuric acid required to saturate 20 c.c. of gas-liquor so as to give ounces of H_2SO_4 required per gallon.

Let x be the number of c.c. of normal sulphuric acid used.

Then x c.c. contain ·049 x grams of H_2SO_4
·049 x grams for 20 c.c. will be

$$\frac{\cdot049 \times 4545\cdot96}{20}\ x \text{ grams } H_2SO_4 \text{ per gallon}$$

or

$$\frac{\cdot049 \times 4545\cdot96}{20 \times 28\cdot3495}\ x \text{ ounces } H_2SO_4 \text{ per gallon.}$$

To find the value of the fraction :—

$$\begin{array}{lll@{\qquad}lll}
\log. \cdot049 & = & \bar{2}\cdot6901961 & \log. 20 & = & 1\cdot3010300 \\
\ \ ,,\ \ 4545\cdot96 & & 3\cdot6576260 & \ \ ,,\ \ 28\cdot3495 & & 1\cdot4525459 \\
\cline{3-3}\cline{6-6}
 & & 2\cdot3478221 & & & 2\cdot7535759 \\
 & & 2\cdot7535759 & & & \\
\cline{3-3}
 & & \bar{1}\cdot5942462 = 0\cdot39287. & & &
\end{array}$$

The log thus obtained may now be abbreviated to $\bar{1}$·59425. Suppose that 32·8 c.c. of normal H_2SO_4 were required, then

$$\begin{array}{lll}
\log. 32\cdot8 & = & 1\cdot51587 \\
 & & \bar{1}\cdot59425 \\
\cline{3-3}
 & & 1\cdot11012 = 12\cdot89 \text{ ounces } H_2SO_4 \text{ per gallon.}
\end{array}$$

Logarithms should not *always* be used in similar cases, since by cancelling out common factors in numerator and denominator some fractions reduce to very simple forms. Thus in a certain calculation the following factor was required :—

Ex. 15. $\dfrac{480 \times 20 \times 30}{144 \times 7000}$ which readily reduces to $\dfrac{2}{7}$.

INDIRECT ANALYSIS.

The methods used are best shown by examples.

Ex. 1. A mixture of chlorides of potassium and sodium weighs 0·9800 gram, and it contains 0·5633 gram of chlorine: to find the amount of each chloride present.

$$\begin{aligned} \text{Let}\quad x &= \text{weight of NaCl present.}\\ y &= \quad ,, \quad \text{KCl} \quad ,, \end{aligned}$$

1 part by weight of NaCl contains 0·6066 Cl
1 ,, ,, KCl ,, 0·4756 Cl
(See Table of Percentage Compositions.)

$$\begin{aligned} \therefore \qquad x + y &= 0{\cdot}9800 \qquad \text{(i)}\\ {\cdot}6066x + {\cdot}4756y &= 0{\cdot}5633 \qquad \text{(ii)}\\ \text{(ii)} \qquad {\cdot}6066x + {\cdot}4756y &= 0{\cdot}5633\\ \text{(i)} \times {\cdot}4756 \qquad {\cdot}4756x + {\cdot}4756y &= 0{\cdot}4661\\ \hline {\cdot}1310x &= 0{\cdot}0972\\ x = \frac{{\cdot}0972}{{\cdot}131} &= 0{\cdot}7420 \text{ gram NaCl.} \end{aligned}$$

From (i) $y = 0{\cdot}9800 - {\cdot}7420 = 0{\cdot}2380$ gram KCl.

Hence the mixture contains

$$\frac{{\cdot}742 \times 100}{{\cdot}98} = 75{\cdot}71\% \text{ NaCl}$$
and $24{\cdot}29\%$ KCl.

The general rule in this case is found as follows: –

Let w = weight of mixed chlorides of sodium and potassium
z = weight of chlorine,
and x = weight of NaCl present.

$$\begin{aligned} \text{Then}\quad {\cdot}6066x + {\cdot}4756(w - x) &= z\\ {\cdot}131x + {\cdot}4756w &= z\\ \frac{{\cdot}131}{{\cdot}4756}x &= \frac{z}{{\cdot}4756} - w\\ \text{or}\quad {\cdot}27544x &= 2{\cdot}1026z - w\\ x &= 3{\cdot}6305(2{\cdot}1026z - w). \end{aligned}$$

Hence the rule: –

Multiply the weight of chlorine present by 2·1026, *and subtract from the product the weight of the mixed chlorides. The remainder multiplied by* 3·6305 *will give the weight of sodium chloride present in the mixture.*

log. 2·1026 = 0·32276 log 3·6305 = 0·55997.

The above rule gives the best results when the chlorides present are in approximately equal amounts.

Ex. 2. 0·9000 gram of a mixture of calcium and strontium carbonates yields 1·1892 grams of sulphates of calcium and strontium. What is the percentage composition of the mixture of carbonates?

Since $CaCO_3 = 100$ and $CaSO_4 = 136$

1 gram of $CaCO_3$ will yield 1·36 grams $CaSO_4$.

Similarly ,, ,, $SrCO_3$,, 1·244 ,, $SrSO_4$.

Then if the mixture contains x grams of $CaCO_3$

and y ,, ,, $SrCO_3$,

x grams $CaCO_3$ become 1·36 x grams $CaSO_4$

and y ,, $SrCO_3$,, 1·244 y ,, $SrSO_4$;

$$x + y = 0·9000 \quad \text{(i)}$$

$$1·36x + 1·244y = 1·1892 \quad \text{(ii)}$$

$$\text{(i)} \times 1·36 \qquad 1·36x + 1·36y = 1·2240$$

$$\text{(ii)} \qquad 1·36x + 1·244y = 1·1892$$

$$·116y = 0·0348$$

$$y = \frac{·0348}{·116} = 0·300$$

$$x = ·9 - ·3 = ·6$$

Hence the mixture consisted of

$$\frac{·3 \times 100}{·9} = 33·3\ \%\ \text{calcium carbonate}$$

and 66·67 % strontium carbonate.

Ex. 3. Volumetric determination of Na_2CO_3 and K_2CO_3 in mixture of the two.

$$Na_2CO_3 + 2HCl = 2NaCl + H_2O + CO_2$$

53 grams of Na_2CO_3 require 36·468 grams of HCl or 2000 c.c. of N/2 HCl. Similarly 69·1 grams K_2CO_3 require an equal volume of the same acid.

Hence 1 gram Na_2CO_3 requires $\frac{2000}{53} = 37·736$ c.c.

1 gram K_2CO_3 ,, $\frac{2000}{69·1} = 28·944$ c.c.

Let 1 gram of a mixture of the above contain x gram of Na_2CO_3 and require n c.c. of N/2 acid, methyl orange being used as indicator. Then

$$37·736x + 28·944(1 - x) = n$$

$$8·792x = n - 28·944$$

$$x = \frac{n - 28·94}{8·79}$$

Note. Indirect methods such as the above give the best results when the substances determined are present in about equal amounts

THE PRECIPITATING POWERS OF A FEW COMMON REAGENTS

1. Ammonium oxalate. $(NH_4)_2C_2O_4, OH_2$.

10 grams per litre.

For 1 gram taken

10 c.c. will precipitate 15·78 per cent. CaO.
,, ,, 28·17 ,, $CaCO_3$.
,, ,, 38·31 ,, $CaSO_4$.
,, ,, 29·11 ,, $Ca_3P_2O_8$.

2. Barium chloride. $BaCl_2, 2OH_2$.

100 grams per litre

For 1 gram taken

10 c.c. will precipitate 13·11 per cent. S.
,, ,, 32·75 ,, SO_3.
,, ,, 40·16 ,, H_2SO_4
,, ,, 55·74 ,, $CaSO_4$.

3. Hydrogen disodium phosphate. $Na_2HPO_4, 12OH_2$.

100 grams per litre.

For 1 gram taken

10 c.c. will precipitate 11·17 per cent. MgO.
,, ,, 23·46 ,, $MgCO_3$
,, ,, 33·51 ,, $MgSO_4$

4 Magnesia Mixture.

Dissolve 10 grams of "Magnesia" in HCl, and add a solution of 200 grams of NH_4Cl in the least possible quantity of water. Add 0·960 ammonia till a slight precipitate forms, and filter. Make up the clear filtrate to 1500 c.c. with distilled water, and add 750 c.c. 0·960 ammonia. Shake well, allow to stand, and filter for use. This solution remains clear on diluting with fairly strong ammonia, and for 1 gram of a substance taken

10 c.c. will precipitate 60 per cent.* $Ca_3P_2O_8$.

Thus, if 1 gram of a Belgian Phosphate were taken for analysis, 10 c.c. would doubtless be sufficient to precipitate the P_2O_5 present, but 15 c.c. would be the proper amount to add, the excess being tested for in the filtrate in the usual way.

5. Ammonium molybdate solution.

Dissolve 50 grams of ammonium molybdate in 200 c.c. of ·960 ammonia at a gentle heat, and pour into a mixture of 400 c.c. strong nitric acid, and 400 c.c. water contained in a beaker standing in water, adding the molybdate solution slowly with constant stirring. Allow the solution to stand, and filter for use.

100 c.c. will precipitate 0·10 gram P_2O_5.

---

* The strength of each batch should be determined and marked on the stock bottle. It usually comes out about 65 per cent.

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS.

C = crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
ALUMINIUM (Al = 27·1)			
Aluminium chloride,	Al_2Cl_6	266·96	Al 20·30 ; Cl 79·70
„ hydroxide,	$Al_2(OH)_6$	156·248	Al 65·41 ; H_2O 34·59
„ oxide,	Al_2O_3	102·2	Al 53·03 ; O 46·97
„ sulphate,	$Al_2(SO_4)_3.18H_2O$	(C) 666·638 (A) 342·386	Al_2O_3 15·33 : SO_3 36·03 : H_2O 48·64
Alum (ammonia),	$Al_2(NH_4)_2(SO_4)_4.24H_2O$	(C) 906·608 (A) 474·524	Al_2O_3 11·27 : $(NH_4)_2O$ 5·76 : SO_3 35·31 . H_2O 49·66
„ potash,	$Al_2K_2(SO_4)_4.24H_2O$	(C) 948·620 (A) 516·640	Al_2O_3 10·77 ; K_2O 9·93 ; SO_3 33·75 . H_2O 45·55
AMMONIUM (NH_4 = 18·042)			
Ammonia,	NH_3	17·034	N 82·25 : H 17·75
Ammonium bromide,	NH_4Br	97·962	NH_3 17·39 ; HBr 82·61
„ carbonate,	$NH_4HCO_3 +$ $NH_2.COONH_4$	157·118	NH_3 32·52 : CO_2 56·01 : H_2O 11·47
„ chloride	NH_4Cl	53·502	NH_3 31·84 : HCl 68·16
„ nitrate.	NH_4NO_3	80·052	NH_3 21·27 . HNO_3 78·73
„ oxalate,	$(NH_4)_2C_2O_4.H_2O$	(C) 142·100 (A) 124·084	(A) NH_3 27·46 : $H_2C_2O_4$ 72·54
„ phosphate,	$(NH_4)_2HPO_4$	132·132	NH_3 25·78 . P_2O_5 53·76 : H_2O 20·46
„ sulphate.	$(NH_4)_2SO_4$	132·144	NH_3 25·78 ; H_2SO_4 74·22
„ thiocyanate,	NH_4CNS	76·132	NH_3 22·38 : H 1·32 : CN 34·17 ; S 42·13

ANTIMONY (Sb = 120·2)			
Antimony trichloride,	$SbCl_3$	226·58	Sb 53·05 : Cl 46·95
Antimonious oxide . .	Sb_2O_3	288·4	Sb 83·36 : O 16·64
Antimony tetroxide, . .	Sb_2O_4	304·4	Sb 78·98 : O 21·02
,, trisulphide. .	Sb_2S_3	336·58	Sb 71·42 : S 28·58
ARSENIC (As = 74·96)			
Arsenic trichloride, .	$AsCl_3$	181·34	As 41·34 : Cl 58·66
Arsenious oxide. .	As_4O_6	395·84	As 75·75 : O 24·25
Arsenic trisulphide. .	As_2S_3	246·10	As 60·92 : S 39·08
,, pentoxide. .	As_2O_5	229·92	As 65·21 : O 34·79
BARIUM (Ba = 137·37)			
Barium carbonate. . .	$BaCO_3$	197·37	BaO 77·71 : CO_2 22·29
,, chloride, . . .	$BaCl_2 . 2H_2O$	C 244·322 A 208·29	C $BaCl_2$ 85·25 : H_2O 14·75 A Ba 65·95 : Cl 34·05
,, nitrate. . .	$Ba(NO_3)_2$	261·3	Ba 52·67 , NO_3 47·33
,, oxide, . .	BaO	153·37	Ba 89·57 : O 10·43
,, hydroxide. . .	$Ba(OH)_2 . 8H_2O$	C 315·514 A 171·386	BaO 48·61 . H_2O 51·39
,, sulphate. .	$BaSO_4$	233·43	BaO 65·70 : SO_3 34·30
BISMUTH (Bi = 208)			
Bismuth chloride, . . .	$BiCl_3$	314·38	Bi 66·16 : Cl 33·84
,, oxide, . .	Bi_2O_3	464	Bi 89·66 : O 10·34
,, nitrate. . . .	$Bi(NO_3)_3 . 5H_2O$	C 484·1 A 394·08	$Bi(NO_3)_3$ 81·38 : H_2O 18·62
BORON (B = 10·9)			
Boric anhydride. . .	B_2O_3	69·8	B 31·23 . O 68·77
,, acid, . .	H_3BO_3	61·924	B_2O_3 56·36 . H_2O 43·64

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued.*

C = crystallized   A = anhydrous.

Name.	Formula	Molecular Weight	Percentage Composition.
CADMIUM Cd = 112·4			
Cadmium chloride, .	. $CdCl_2 . H_2O$	(C) 201·336 (A) 183·320	$CdCl_2$ 91·05 . H_2O 8·95
,, oxide, .	. CdO	128·4	Cd 87·54 : O 12·46
,, sulphide, .	. CdS	144·46	Cd 77·80 : S 22·20
CALCIUM Ca = 40·07			
Calcium chloride, .	. $CaCl_2 . 6H_2O$	(C) 219·056 (A) 110·99	(A) Ca 36·10 : Cl 63·90
,, carbonate, .	. $CaCO_3$	100·07	CaO 56·03 : CO_2 43·97
,, fluoride, .	. CaF_2	78·07	Ca 51·33 : F 48·67
,, hydroxide, .	$Ca(OH)_2$	74·09	CaO 75·68 : H_2O 24·32
,, nitrate, .	$Ca(NO_3)_2 . 4H_2O$	(C) 236·154 (A) 164·090	(A) CaO 34·17 . N_2O_5 65·83
,, oxide, .	. CaO	56·07	Ca 71·46 : O 28·54
Calcium sulphate, .	. $CaSO_4 . 2H_2O$	(C) 172·182 (A) 136·130	(C) CaO 32·57 . SO_3 46·51 : H_2O 20·92 (A) CaO 41·19 . SO_3 58·81
Monocalcium phosphate	. $CaH_4(PO_4)_2$	234·182	CaO 23·94 : P_2O_5 60·67 ; H_2O 15·39
Tricalcium ,,	$Ca_3(PO_4)_2$	310·29	CaO 54·21 : P_2O_5 45·79
Calcium sulphide, .	. CaS	72·13	Ca 55·55 : S 44·45
CARBON C = 12			
Carbon monoxide, .	. CO	28	C 42·86 : O 57·14
,, dioxide,	CO_2	44	C 27·27 O 72·73

CHROMIUM ($Cr = 52$)			
Chromic chloride, . .	Cr_2Cl_6	316·78	Cr 32·83 ; Cl 67·17
,, oxide, . . .	Cr_2O_3	152	Cr 68·42 ; O 31·58
,, sulphate, . .	$Cr_2(SO_4)_3$	392·18	Cr_2O_3 38·75 ; SO_3 61·25
COBALT ($Co = 58·97$)			
Cobaltous chloride, . .	$CoCl_2$	129·59	Co 45·40 ; Cl 54·60
,, nitrate, . .	$Co(NO_3)_2 . 3H_2O$	(C) 237·[illegible] (A) [illegible]	CoO 31·63 ; N_2O_5 45·57 ; H_2O 22·80
Cobalt monoxide, . .	CoO	74·97	Co 78·66 ; O 21·34
COPPER ($Cu = 63·17$)			
Cuprous chloride, . .	Cu_2Cl_2	198·06	Cu [illegible] ; Cl 35·[illegible]
,, oxide, . .	Cu_2O	142·34	Cu 88·82 ; O 11·18
,, sulphide, . .	Cu_2S	158·[illegible]	Cu 79·86 ; S 20·14
Cupric chloride, . .	$CuCl_2 . 2H_2O$	(C) 170·[illegible]2 (A) 134·[illegible]	Cu 47·27 ; Cl 52·73
,, oxide . .	CuO	79·57	Cu 79·89 ; O 20·11
,, sulphide, . .	CuS	95·6[illegible]	Cu 66·47 ; S 33·53
,, sulphate, . .	$CuSO_4 . 5H_2O$	(C) 249·71 (A) 159·6[illegible]	CuO 31·88 ; SO_3 32·08 ; H_2O 36·08 Cu 25·[illegible]
HYDROGEN ($H = 1·008$)			
Hydrogen chloride, . .	HCl	36·438	H 2·76 ; Cl 97·24
,, bromide, . .	HBr	80·928	H 1·25 ; Br 98·75
,, iodide, . .	HI	127·928	H 0·79 ; I 99·21
,, nitrate, . .	HNO_3	63·018	N_2O_5 85·71 ; H_2O 14·29
,, sulphate, . .	H_2SO_4	98·076	SO_3 81·63 ; H_2O 18·37

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued.*

C = crystallized. A = anhydrous.

Name.	Formula	Molecular Weight.	Percentage Composition.
IRON (Fe = 55·84)			
Ferrous chloride,	$FeCl_2$	126·76	Fe 44·05 : Cl 55·95
,, carbonate,	$FeCO_3$	115·84	FeO 62·02 : CO_2 37·98
,, oxide,	FeO	71·84	Fe 77·73 ; O 22·27
,, sulphate	$FeSO_4 . 7H_2O$	C 278·012 A 151·90	FeO 25·84 : SO_3 28·80 : H_2O 45·36 (Fe [illegible])
,, ammonium sulphate,	$Fe(NH_4)_2(SO_4)_2 . 6H_2O$	C 392·14 A 284·01	[illegible]·7022 gm. contains 1 gm. Fe
,, sulphide.	FeS	87·90	Fe 63·52 : S 36·48
Ferric chloride.	Fe_2Cl_6	324·44	Fe 34·42 ; Cl 65·58
,, oxide.	Fe_2O_3	159·68	Fe 69·94 : O 30·06
Triferric tetroxide,	Fe_3O_4	231·52	Fe 72·36 : O 27·64
Iron disulphide.	FeS_2	119·96	Fe 46·54 : S 53·46
Ferric sulphate	$Fe_2(SO_4)_3$	399·86	Fe_2O_3 39·93 : SO_3 60·07
LEAD (Pb = 207·2)			
Lead acetate,	$Pb(C_2H_3O_2)_2 . 3H_2O$	C 379·29 A 325·248	$Pb(C_2H_3O_2)_2$ 85·75 : H_2O 14·25
,, carbonate,	$PbCO_3$	267·2	PbO 83·53 : CO_2 16·47
,, chloride,	$PbCl_2$	278·12	Pb 74·49 ; Cl 25·51
,, chromate,	$PbCrO_4$	323·2	PbO 69·05 : CrO_3 30·95
,, nitrate.	$Pb(NO_3)_2$	331·22	PbO 67·38 : N_2O_5 32·62
Plumbic oxide,	PbO	223·2	Pb 92·83 : O 7·17
,, dioxide.	PbO_2	239·2	Pb 86·62 : O 13·38
Triplumbic tetroxide.	Pb_3O_4	685·6	Pb 90·66 : O 9·34
Lead sulphide.	PbS	239·27	Pb 86·59 : S 13·41
,, sulphate.	$PbSO_4$	303·27	PbO 73·59 : SO_3 26·41

MAGNESIUM (Mg = 24·32)			
Magnesium chloride . .	$MgCl_2, 6H_2O$	(C) 203·336 (A) 95·240	(A) Mg 25·54 : Cl 74·46
" carbonate, .	$MgCO_3$	84·32	MgO 47·82 : CO_2 52·18
" oxide. . . .	MgO	40·32	Mg 60·32 ; O 39·68
" nitrate, . . .	$Mg(NO_3)_2, 6H_2O$	(C) 256·436 (A) 148·336	(A) MgO 27·18 : N_2O_5 72·82
" sulphate, . .	$MgSO_4, 7H_2O$	(C) 246·492 (A) 120·38[illegible]	MgO 16·36 ; SO_3 32·48 ; H_2O 51·16
Magnesium ammonium phosphate	$Mg(NH_4)_2(PO_4)_2, 12H_2O$	(C) 4[illegible] (A) 274·[illegible]	
" pyrophosphate. .	$Mg_2P_2O_7$	222·72	MgO 36·21 : P_2O_5 63·79
MANGANESE (Mn = 54·93)			
Manganous carbonate, . .	$MnCO_3$	114·93	MnO 61·72 : CO_2 38·28
" chloride. .	$MnCl_2, 4H_2O$	(C) 197·[illegible]4 (A) 125·8[illegible]	(A) Mn 4[illegible] : Cl 56·35
" oxide. .	MnO	70·93	Mn 77·44 : O 22·56
" sulphate. .	$MnSO_4, 5H_2O$	(C) 241·07 (A) 15[illegible]	(A) MnO 4[illegible]·97 : SO_3 53·03
" sulphide. . . .	MnS	87·00	Mn 63·1[illegible] : S 3[illegible]
Manganese dioxide. . .	MnO_2	86·93	Mn 63·19 : O 36·81
" sesquioxide, .	Mn_2O_3	157·86	Mn 69·59 : O 30·41
Trimanganic tetroxide. .	Mn_3O_4	228·79	Mn 72·03 ; O 27·97
MERCURY (Hg = 200·6)			
Mercurous chloride, . . .	Hg_2Cl_2	472·12	Hg 84·98 : Cl 15·02
" nitrate, . .	$Hg_2(NO_3)_2, 2H_2O$	(C) 561·252 (A) 525·220	Hg_2O 74·33 : N_2O_5 19·25 : H_2O 6·42
" oxide, . . .	Hg_2O	417·2	Hg 96·16 : O 3·84
Mercuric chloride. . . .	$HgCl_2$	271·52	Hg 73·88 ; Cl 26·12

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued.*

C = crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
MERCURY (Hg = 200·6)—*contd.*			
Mercuric nitrate,	$2Hg(NO_3)_2 . H_2O$	(C) 667·256 A 649·240	HgO 64·92 ; N_2O_5 32·38 . H_2O 2·70
" oxide,	HgO	216·6	Hg 92·61 ; O 7·39
" sulphide,	HgS	232·66	Hg 86·22 ; S 13·78
" sulphate,	$HgSO_4$	296·66	HgO 73·01 ; SO_3 26·99
NICKEL (Ni = 58·68)			
Nickel chloride,	$NiCl_2$	129·6	Ni 45·28 ; Cl 54·72
" monoxide,	NiO	74·68	Ni 78·58 ; O 21·42
" sulphate,	$NiSO_4 . 7H_2O$	(C) 280·852 (A) 154·740	NiO 26·59 ; SO_3 28·51 . H_2O 44·90
" monosulphide,	NiS	90·74	Ni 64·66 ; S 35·34
" nitrate,	$Ni(NO_3)_2 . 6H_2O$	(C) 290·796 A 182·700	$Ni(NO_3)_2$ 62·83 . H_2O 37·17
PHOSPHORUS (P = 31·04)			
Hypophosphorous acid,	$HP(OH)_2$	66·064	
Phosphorous	H_2PHO_3	82·064	
Phosphoric	H_3PO_4	98·064	P_2O_5 72·44 . H_2O 27·56
Metaphosphoric	HPO_3	80·048	P_2O_5 88·75 . H_2O 11·25
Pyrophosphoric	$H_4P_2O_7$	178·112	P_2O_5 79·77 : H_2O 20·23
Phosphorus pentoxide,	P_2O_5	142·08	P 43·69 ; O 56·31
PLATINUM (Pt = 195·2)			
Platinum tetrachloride,	$PtCl_4$	337·04	Pt 57·92 ; Cl 42·08
Ammonium platinochloride,	$(NH_4)_2PtCl_6$	444·044	Pt 43·96 ; NH_3 7·67 (N 6·31)
Potassium "	K_2PtCl_6	486·16	Pt 40·15 ; Cl 43·77 . K 16·08 (KCl 30·67 = K_2O 19·38)

POTASSIUM (K = 39·1)			
Potassium acetate,	$KC_2H_3O_2$	98·124	
" bromide,	KBr	119·2	K 32·85 ; Br 67·15
" carbonate,	K_2CO_3	138·2	K_2O 68·16 ; CO_2 31·84
" bicarbonate,	$KHCO_3$	100·108	K_2O 47·05 ; CO_2 43·95 ; H_2O 9·00
" chlorate,	$KClO_3$	122·56	K 31·90 ; Cl 28·93 ; O 39·17
" chloride,	KCl	74·56	K 52·44 ; Cl 47·56
" cyanide,	KCN	65·11	K 60·05 ; CN 39·95
" chromate,	K_2CrO_4	194·2	K_2O 48·51 ; CrO_3 51·49
" dichromate,	$K_2Cr_2O_7$	294·2	K_2O 32·02 ; CrO_3 67·98
" ferrocyanide,	$K_4Fe(CN)_6 . 3H_2O$	H 422·318 A 36[illegible]	K 37·03 ; Fe 13·22 ; CN 36·95 ; H_2O 12·80
" ferricyanide,	$K_3Fe(CN)_6$	32[illegible]	K 35·63 ; Fe 16·96 ; CN 47·41
" hydroxide,	KOH	56·108	K_2O 83·95 ; H_2O 16·05
" iodide,	KI	166·02	K 23·55 ; I 76·45
" nitrate,	KNO_3	101·11	K_2O 46·58 ; N_2O_5 53·42
" nitrite,	KNO_2	85·11	K_2O 55·34 ; N_2O_3 44·66
" oxide,	K_2O	94·2	K 83·01 ; O 16·99
" permanganate,	$KMnO_4$	158·13	K_2O 29·80 ; Mn_2O_7 70·20
" sulphate,	K_2SO_4	174·26	K_2O 54·05 ; SO_3 45·95
" bisulphate,	$KHSO_4$	136·168	K_2O 34·59 ; SO_3 58·80 ; H_2O 6·61
" sulphide,	K_2S	110·28	K 70·9[illegible] ; S [illegible]
" sulphite,	$K_2SO_3 . 2H_2O$	H 194·2 A 158·2	K_2O 48·48 ; SO_2 32·97 ; H_2O 18·55
" thiocyanate,	KCNS	97·17	K 40·23 ; CNS 59·77
SILICON (Si = 28·3)			
Silica,	SiO_2	60·3	Si 46·93 ; O 53·07
SILVER (Ag = 107·88)			
Silver bromide,	AgBr	187·8	Ag 57·44 ; Br 42·56
" chloride,	AgCl	143·34	Ag 75·26 ; Cl 24·74

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued.*

C = crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight	Percentage Composition.
SILVER (Ag = 107·88)—*contd.*			
Silver nitrate,	$AgNO_3$	169·89	Ag 63·50 : NO_3 36·50
,, sulphide,	Ag_2S	247·82	Ag 87·06 : S 12·94
,, sulphate,	Ag_2SO_4	311·82	Ag_2O 74·32 : SO_3 25·68
SODIUM (Na = 23)			
Sodium acetate,	$NaC_2H_3O_2 . 3H_2O$	(C) 136·072	
,, aluminate	$Na_2Al_2O_4$	164·2	Na_2O 37·76 : Al_2O_3 62·24
,, borate,	$Na_2B_4O_7 . 10H_2O$	(C) 381·76 (A) 201·6	(C) Na_2O 16·24 : B_2O_3 36·57 : H_2O 47·49 (A) Na_2O 30·75 : B_2O_3 69·25
,, carbonate,	$Na_2CO_3 . 10H_2O$	(C) 286·16 (A) 106	(C) Na_2O 21·67 : CO_2 15·37 : H_2O 62·96 (A) Na_2O 58·49 ; CO_2 41·51
,, bicarbonate,	$NaHCO_3$	84·008	Na_2O 36·91 ; CO_2 52·38 : H_2O 10·71
,, chloride,	NaCl	58·46	Na 39·34 : Cl 60·66
,, chromate,	Na_2CrO_4	162	Na_2O 38·27 : CrO_3 61·73
,, hydroxide,	NaOH	40·008	Na_2O 77·48 ; H_2O 22·52
,, nitrate,	$NaNO_3$	85·01	Na_2O 36·47 : N_2O_5 63·53 N 16·48
,, nitrite,	$NaNO_2$	69·01	Na_2O 44·92 : N_2O_3 55·08
,, oxide,	Na_2O	62	Na 74·19 : O 25·81
,, phosphate,	$Na_2HPO_4 . 12H_2O$	(C) 358·240 (A) 142·048	Na_2O 17·31 : P_2O_5 19·83 : H_2O 62·86
,, sulphate,	$Na_2SO_4 . 10H_2O$	(C) 322·22 (A) 142·06	(C) Na_2O 19·24 : SO_3 24·85 : H_2O 55·9 (A) Na_2O 43·64 : SO_3 56·36
,, bisulphate	$NaHSO_4$	120·068	Na_2O 25·82 : SO_3 66·68 : H_2O 7·50

SODIUM ($Na = 23$)—*continued.*			
Sodium sulphide,	Na_2S	78·06	Na 58·92 : S 41·08
,, sulphite,	$Na_2SO_3, 7H_2O$	(C) 252·172 (A) 126·06	Na_2O 24·59 : SO_2 25·41 : H_2O 50·00
,, thiosulphate,	$Na_2S_2O_3, 5H_2O$	(C) 248·20 (A) 158·12	Na_2O 24·98 ; S 12·92 ; SO_2 25·81 ; H_2O 36·29
STRONTIUM ($Sr = 87·63$)			
Strontium carbonate,	$SrCO_3$	147·63	SrO 70·20 ; CO_2 29·80
,, chloride,	$SrCl_2, 6H_2O$	(C) 266·646 (A) 158·55	Sr 32·86 ; Cl 26·60 ; H_2O 40·54
,, nitrate,	$Sr(NO_3)_2$	211·65	SrO 48·96 ; N_2O_5 51·04
,, oxide,	SrO	103·63	Sr 84·55 ; O 15·44
SULPHUR ($S = 32·06$)			
Sulphur dioxide,	SO_2	64·06	S 50·05 ; O 49·95
,, trioxide,	SO_3	80·06	S 40·05 ; O 59·95
Sulphuretted hydrogen,	H_2S	34·076	H 5·[illegible] ; S 94·[illegible]
TIN ($Sn = 118·7$)			
Stannous chloride,	$SnCl_2, 2H_2O$	(C) 225·652 (A) 189·62	Sn 52·[illegible] ; Cl 31·[illegible] ; H_2O 15·97
,, oxide,	SnO	134·7	Sn 88·12 ; O 11·88
Stannic oxide,	SnO_2	150·7	Sn 78·77 ; O 21·23
ZINC ($Zn = 65·37$)			
Zinc carbonate,	$ZnCO_3$	125·37	ZnO 64·90 ; CO_2 35·10
,, chloride,	$ZnCl_2$	136·29	Zn 47·96 ; Cl 52·04
,, oxide,	ZnO	81·37	Zn 80·34 ; O 19·66
,, sulphate,	$ZnSO_4, 7H_2O$	(C) 287·512 (A) 161·43	(C) ZnO 28·30 : SO_3 27·85 : H_2O 43·85 (A) ZnO 50·40 ; SO_3 49·60
,, sulphide	ZnS	97·43	Zn 67·09 ; S 32·91
WATER,	H_2O	18·016	H 11·19 : O 88·81

Notes on Indicators.

I.—Litmus solution A solution of a carbonate whilst being titrated should be boiled to expel the free CO_2, otherwise it is easy to overstep the exact point of neutrality. The titration cannot be done by gas-light.

According to B. Reinitzer (see Abstract, *Analyst*, 1894, p. 255) litmus is the most serviceable indicator, excelling methyl orange in sharpness of change of colour and sensitiveness, while it possesses an advantage over phenol-phthalein in being capable of being used in the presence of ammonium salts. Good litmus should be used; the solution must be boiled for seven or eight minutes and then neutralized with HCl, so that the wine red colour remains even on further boiling: the solution is then cooled, and an equal volume of strong alcohol added. The stock solution should be kept in a bottle with a delivery pipette inserted through the cork. The final change of colour is sharpest when the liquid to be titrated is boiled for seven or eight minutes and then well cooled. Lunge has found (see Abstract *Analyst*, 1895, p. 65) that litmus is only twice as sensitive as methyl orange, against eight times as claimed by Reinitzer. With normal acid practically identical results are obtained, but methyl orange is preferable on account of its speed and the precautions to be observed in the use of litmus. It is only with decinormal acid that litmus is undoubtedly superior, and Reinitzer's method of titration must be observed. Whatever indicator be used the fluid must be cold when titrated.

If it is desired to titrate carbonates, using litmus or phenol-phthalein as indicator, the boiling should be carried out in vessels of porcelain, platinum or silver: for even Jena glass is attacked by hot soda solutions (Lunge).

II.- Methyl orange (the sodium salt of dimethyl amido-azo-benzene-sulphonic acid).

Solution. 0·5 gram in a litre of distilled water.

Unlike litmus, this indicator is unaffected by CO_2, H_2S, boric, arsenious, hydrocyanic, oleic, stearic, palmitic, and carbolic acids, &c. It must not be used for organic acids; nor in the presence of nitrous acid or nitrites, which decompose it. It acts admirably with mineral acids, and with ammonia and its salts. Ordinary temperatures should be observed.

Colour reaction. -Faint yellow if alkaline, pink if acid.

The use of methyl orange is recommended by Lunge (1903) for all cases except that of weak acids, for which phenol-phthalein should be employed. The strength of solutions titrated should not be less than one-fifth normal.

As methyl orange is often adulterated with dextrin and other substances, every new lot purchased should be carefully tested, especially as to whether it gives a sharp change of colour with a mineral acid.

III.- Phenol-phthalein ($C_{20}H_{14}O_4$).

Solution. Dissolve 4 grams in 600 c.c. of strong alcohol, then add gradually with constant stirring 400 c.c. of distilled water.

It is useless for the titration of free ammonia or its compounds, or for the fixed alkalies when salts of ammonia are present. Unlike methyl orange, it is specially useful in titrating all varieties of organic acids—viz., oxalic, acetic, citric, tartaric, &c. It may be used either in alcoholic solutions or in mixtures of alcohol and ether. It gives no colour with bicarbonates.

Colour reaction. Colourless in neutral or acid liquids, but rendered purple-red by faint excess of caustic alkali.

IV. Cochineal solution.

Solution.- Digest one part of powdered cochineal with 10 parts of 25 per cent. alcohol.

It is not very much modified in colour by CO_2, and may be used by gas light. Most useful in titrating solutions of the alkaline earths, such as lime and baryta-water. Inapplicable in the presence of even traces of Fe or Al compounds or acetates.

Colour reaction. Turned violet by alkalies; the original yellowish red colour being restored by mineral acids.

V. Phenacetolin.

Solution. Two grams in a litre of alcohol.

This indicator may be used to estimate the amount of KHO or NaHO in the presence of K_2CO_3 or Na_2CO_3, or of CaO in the presence of $CaCO_3$.

Colour reaction —

With NH_3 and normal alkaline carbonates dark pink.
,, bicarbonates — intense pink.
,, mineral acids —golden yellow.

VI. Rosolic Acid ($C_{20}H_{16}O_3$).

Solution. Two grams in a litre of 50 per cent. alcohol.

This indicator is excellent for all the mineral, but useless for the organic acids, except oxalic. It may be relied on for the neutralization of SO_2 with ammonia to normal sulphite.

Colour reaction. The pale yellow colour is unaffected by acids, but changed to violet-red by alkalies.

VII.—Lacmoid.

Solution. Three grams may be dissolved in a litre of dilute alcohol, but Forster recommends the addition of 5 grams of naphthol green to the above. The effect is to produce a more decided blue colour with alkalies than is given by lacmoid alone.

Colour reaction.— Blue in alkaline, red in acid, solution.

VIII.--Congo Red.

Solution.- One gram in 100 c.c. of 10 per cent. alcohol. Specially useful in determining free mineral acids in the presence of most organic acids.

Colour reaction. Red in alkaline solution, turning blue with excess of acid.

Turmeric Paper.-- Digest one part of powdered turmeric with six parts of weak alcohol, filter, and steep some filter paper in the filtrate. The paper, when dry, must exhibit a fine yellow tint, and be readily wetted by aqueous fluids. Cut into strips and keep in a well-stoppered bottle covered with black paper.

I. Imperial System.

Avoirdupois Weight.

16 drams (dr.) = 1 ounce (oz.) = 437·5 grains* | log. 437·5 = 2·640 9781
16 ounces = 1 pound (lb.) = 7000 ,, | log. 7000 = 3·845 0980
14 pounds = 1 stone
28 ,, = 1 quarter
100 ,, = 1 cental
4 quarters = 1 hundredweight (cwt.) = 112 lb. log. 112 = 2·049 2180
20 cwts. = 1 ton = 2240 lb. log. 2240 = 3·350 2480

Note. 1 dram = 27·34375 grains (log. 1·436 8581).

24 grains (and its multiples 48, 72, 120, and 240 grains) are legal weights and are commonly called *pennyweights*.

Troy Weight.

1 troy ounce (oz. tr.) = 480 grains* | log. 2·681 2412

Weights less than a troy ounce are expressed as decimals of an ounce, not in grains. For greater weights, ounces only are used, there being no troy pound.

Apothecaries' Weight.

20 grains* (gr.) = 1 scruple (℈)
3 scruples or 60 grains = 1 drachm (ʒ)
8 drachms or 480 grains = 1 ounce (℥)

Apothecaries' Measures.

60 minims (min.) = 1 fluid drachm (fl. dr. or f ʒ)
8 fluid drachms = 1 fluid ounce (fl. oz. or f ℥)
20 fluid ounces = 1 pint (O)†
8 pints = 1 gallon (C)‡

Relations of Apothecaries' Measures to Weights.

(All liquids to be measured at 62° Fah.)

			Logarithms
1 minim is the measure of	0·9115	grain weight of water	1·959 7368
1 fluid drachm ,,	54·687	grains ,,	1·737 8881
1 fluid ounce ,,	437·5	,, ,,	2·640 9781
1 pint ,,	8750	,, ,,	3·942 0081
1 gallon ,,	70000§	,, ,,	4·845 0980

	Logarithms
1 pint = 34·6829 cubic inches	1·540 1151
1 gallon = 277·463 ,,	2·443 2051
1 gallon = 0·16057 cubic foot	1·205 6614

	Logarithms
Cubic inches × 0·02883 = pints	2·459 8819
,, × 0·003604 = gallons	3·556 7949
Cubic feet × 6·228 = gallons	0·794 3386

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* The grain is common to Avoirdupois, Troy, and Apothecaries' Weights.

† O = octarius, *i.e.*, one eighth ‡ C = (Roman) Congius.

§ According to H. J. Chaney

One gallon once distilled water weighs 70000·5 grains.
,, twice ,, ,, 70000·0 ,,
,, well water weighs 70066·6 ,,

WEIGHTS AND MEASURES—*continued.*

Long Measure.

12 inches = 1 foot
3 feet = 1 yard
6 feet = 1 fathom
5½ yards = 1 rod, pole, or perch
4 poles = 1 chain
40 poles = 1 furlong
8 furlongs = 1 mile = 1760 yards

Square Measure.

144 square inches = 1 square foot
9 ,, feet = 1 ,, yard
30¼ ,, yards = 1 rod, pole, or perch
40 ,, poles = 1 rood
4 roods = 1 acre = 4840 square yards
640 acres = 1 square mile

Cubic or Solid Measure.

1728 cubic inches = 1 cubic foot | log 1728 = 3·237 5437
27 ,, feet = 1 ,, yard | log 27 = 1·431 3638

		Logarithms.
1 cubic inch of water* at 62° Fahr. weighs	252·286 grains	2·401 8931
,, ,, ,,	0·57665 oz. (av.)	1·760 9150
,, ,, ,,	0·036011 lb.	2·556 7951
1 cubic foot ,, ,,	996·458 oz. (av.)	2·998 4587
,, ,, ,,	62·2786 lb.	1·794 3388
,, ,, ,,	28·2191 kilograms	1·45[illegible] [illegible]046
1 cubic yard ,, ,,	0·75068 tons †	1·875 [illegible]16

Measures of Capacity.

4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon

Ale, Beer, and Porter Measure.

The following measures between square brackets, though in common use, are not officially recognized:—

[4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
9 gallons = 1 firkin
2 firkins = 1 kilderkin = 18 gallons
2 kilderkins = 1 barrel 36 ,,
3 ,, = 1 hogshead 54 ,,
3 hogsheads = 1 butt 108 ,,]

Dry Measure.

2 pints = 1 quart
4 quarts = 1 gallon
2 gallons = 1 peck
4 pecks = 1 bushel
8 bushels = 1 quarter
4 quarters = 1 chaldron

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* *i.e.*, distilled water freed from air.

† One ton of water (224 gallons) occupies 35·967 cubic feet (log 1·55591).

WEIGHTS AND MEASURES—*continued.*

II. WEIGHTS AND MEASURES OF THE METRIC SYSTEM.

Measures of Weight.

The metric standard of weight is the kilogram, which is represented by a certain iridio-platinum weight deposited with the Board of Trade

One-thousandth part of this is the gram which constitutes the *practical* unit of weight, the fractions and multiples of which are thus designated:—

0·1 gram = 1 decigram | 10 grams = 1 dekagram
0·01 ,, = 1 centigram | 100 ,, = 1 hectogram
0·001 ,, = 1 milligram | 1000 ,, = 1 kilogram

Measures of Capacity.

The standard litre is the volume of a kilogram of pure water at 4° C. under standard barometric pressure

The value of the litre in terms of the cubic centimetre has been the subject of numerous experiments. Very exact measurements made during the last few years have shown that

1 litre = 1000·028 cubic centimetres (c.c., c. cm., or cm³.)

Hence in all but the most refined experiments the volume of one cubic centimetre may be taken as one-thousandth part of that of the litre (*i.e.* one millilitre or mil*).

1 decilitre = 100 c.c., 1 centilitre = 10 c.c.

Measures of Length.

The metre is represented by the length, at 0° C., of a certain iridio-platinum bar deposited with the Board of Trade. The fractions and multiples are as follows:—

0·1 metre = 1 decimetre (dm.) | 10 metres = 1 dekametre
0·01 ,, = 1 centimetre (cm.) | 100 ,, = 1 hectometre
0·001 ,, = 1 millimetre (mm.) | 1000 ,, = 1 kilometre

0·001 mm. = 1 micron (*μ*) = 0·00004 inch (nearly).

0·000001 mm = 1 micromillimetre† (*μμ*) = 0·00000004 inch (nearly).

TABLES FOR THE CONVERSION OF METRIC INTO IMPERIAL MEASURES AND *vice versa.*

A. *Linear Measure.*

Metric into Imperial.		Logarithms.
1 millimetre (mm.)	0·0393701 inches . .	2·595 1666
1 centimetre (cm.) =	0·393701 ,, . .	1·595 1666
1 decimetre (dm.) =	3·937011 ,, . . .	0·595 1666
1 metre (m.) =	39·370113 ,, . .	1·595 1666
,, =	3·280843 feet . . .	0·515 9855
,, =	1·093614 yards . . .	0·038 8642
1 kilometre (km.) =	1093·61126 ,, . . .	3·038 8642
,, =	0·621372 mile . . .	1·793 3517

*** 33 cm. = 13 inches within 0·008 inch in deficiency.
127 cm. = 50 inches within 0·00005 inch in excess.

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* For pharmaceutical purposes the terms mil (= millilitre), decimil (0·1 mil) and centimil (0·01 mil) have been legalized and are in regular use.

† The prefix *micro* always indicates a millionth part of the unit.

WEIGHTS AND MEASURES—*continued.*

Imperial into Metric	Logarithms
1 inch = 2·540 centimetres	0·404 8337
1 foot = 30·480 „	1·484 0150
1 yard = 0·914399 metre	$\bar{1}$·961 1357
1 mile = 1·6093 kilometres	0·206 6370

₊ 1613 metres = 1764 yards, within 0·008 inch in deficiency.

mm	Inch	Metres	Feet	Inches	mm	Feet	Metres
1	·03937	1	3·2808	1	25·4	1	0·3048
2	·07874	2	6·5616	2	50·8	2	0·6096
3	·11811	3	9·8424	3	76·2	3	0·9144
4	·15748	4	13·1232	4	101·6	4	1·2192
5	·19685	5	16·4040	5	127·0	5	1·5240
6	·23622	6	19·6848	6	152·4	6	1·8288
7	·27559	7	22·9656	7	177·8	7	2·1336
8	·31496	8	26·2464	8	203·2	8	2·4384
9	·35433	9	29·5272	9	228·6	9	2·7432

B. *Square Measure.*

Metric into Imperial		Logarithms
1 square decimetre (dm².)	= 15·500 square inches	1·190 3317
1 square metre (m².) or centiare	= 10·7639 square feet	1·031 9697
„	= 1·1960 square yards	0·077 7312
1 are (100 square metres)	= 119·60 „	2·077 7312
„	= 0·024711 acres	$\bar{2}$·392 8903

Imperial into Metric	Logarithms
1 square inch = 6·4516 square centimetres	0·809 6674
1 square foot = 9·2903 square decimetres	0·968 0297
1 square yard = 0·836126 square metres	$\bar{1}$·922 2717
1 acre = 0·40468 hectare	$\bar{1}$·607 1117
1 square mile (640 acres) = 259·00 hectares	2·413 2998

C. *Cubic Measure and Measures of Capacity.*

Metric into Imperial, etc.		Logarithms
1 cubic centimetre (c.c.)	= 0·0610 cubic inch	$\bar{2}$·785 3298
„	= 16·894 minims	1·227 7325
„	= 0·28157 fluid drachm	$\bar{1}$·449 5864
„	= 0·035196 fluid ounce	$\bar{2}$·546 4933
1 litre	= 61·024 cubic inches	1·785 5007
„	= 35·1960 fluid ounces	1·546 4933
„	= 1·75980 pints	0·245 4633
„	= 0·2200 gallon	$\bar{1}$·342 4227
1 hectolitre	= 2·75 bushels	0·439 3327
1 cubic metre (m³.)	= 35·3148 cubic feet	1·547 9567
„	= 1·307954 cubic yards	0·116 5924

₊ 25 litres = 44 pints within 0·005 pint in deficiency.
5 dekalitres = 11 gallons within 0·002 gallon in deficiency.

WEIGHTS AND MEASURES—*continued.*

c.c.	Cubic Inch.
1	0·061024
2	0·122048
3	0·183072
4	0·244096
5	0·305120
6	0·366144
7	0·427168
8	0·488192
9	0·549216

Litres	Fluid Ounces	Pints	Gallons.
1	35·1960	1·7598	0·22
2	70·3920	3·5196	0·44
3	105·5880	5·2794	0·66
4	140·7840	7·0392	0·88
5	175·9800	8·7990	1·10
6	211·1760	10·5588	1·32
7	246·3720	12·3186	1·54
8	281·5680	14·0784	1·76
9	316·7640	15·8382	1·98

	Imperial into Metric.	Logarithms
1 cubic inch	16·387 cubic centimetres	1·214 4995
1 cubic foot	28·317 cubic decimetres	1·452 0472
1 cubic yard	= 0·764553 cubic metre	1·883 4076

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1 minim	= 0·059 cubic centimetre	2·770 8520
1 fluid drachm	= 3·552 cubic centimetres	0·550 4730
1 fluid ounce	28·4123 ,,	1·453 5064
1 pint	568·25 ,,	2·754 5394
1 quart	1·13649 litres	0·055 5656
1 gallon	= 4·5459631 litres	0·657 6260

Cubic Inches	Cubic Centimetres
1	16·387
2	32·774
3	49·161
4	65·548
5	81·935
6	98·322
7	114·709
8	131·096
9	147·483

Fluid Ounces.	Cubic Centimetres
1	28·4123
2	56·8246
3	85·2369
4	113·6492
5	142·0615
6	170·4738
7	198·8861
8	227·2984
9	255·7107

Pints.	Litres.
1	0·56825
2	1·13650
3	1·70475
4	2·27300
5	2·84125
6	3·40950
7	3·97775
8	4·54600
9	5·11425

Gallons	Litres
1	4·54596
2	9·09192
3	13·63788
4	18·18384
5	22·72980
6	27·27576
7	31·82172
8	36·36768
9	40·91364

Note.—The following measure, though not recognized officially, is much used in certain trades:—1 barn gallon = 17 pints = 9·6602 litres.

WEIGHTS AND MEASURES—*continued.*

	Metric into Imperial.	Logarithms.
1 milligram	= 0·01543 grain	2·188 4324
1 centigram	= 0·15432 grain	1·188 4324
1 decigram	1·54324 grains	0·188 4324
1 gram	= 15·43236 grains	1·188 4324
,,	0·564383 dram avoirdupois	1·751 5739
,,	= 0·035274 ounce avoirdupois	2·547 4547
,,	= 0·25721 drachm (apothecaries')	1·410 3878
,,	0·0321507 ounce troy	2·507 1905
1 kilogram	15432·3564 grains	4·188 4324
,,	35·2740 ounces avoirdupois	1·547 4547
,,	2·2046223 lb.	0·343 334
,,	32·15074 ounces troy	1·507 1910
1 quintal (100 kilog.)	1·968 cwt.	0·294 025
1 tonne (1000 kilog.)	= 0·9842 ton	1·993 083

Grams.	Grains.	Oz (Av.)	Oz (Troy)	Kilograms	Pounds
1 =	15·43236 =	0·035274 =	0·0321507	1 =	2·20462
2 =	30·86472 =	0·070548 =	0·0643014	2	4·40924
3 =	46·29708	0·105822	0·0964521	3	6·61386
4	61·72944 =	0·141096	0·1286028	4	8·81848
5 =	77·16180	0·176370	0·1607535	5	11·02310
6	92·59416	0·211644 =	0·1929042	6	13·22772
7	108·02652 =	0·246918 =	0·2250549	7	15·43234
8 =	123·45888 =	0·282192	0·2572056	8	17·63696
9 =	138·89124 =	0·317466	0·2893563	9 =	19·84158

	Imperial into Metric	Logarithms
1 grain	= 0·0648 gram	2·811 5750
1 drachm (apoth.)	= 3·888 grams	0·589 7263
1 ounce troy	= 31·1035 grams	1·492 8093
1 dram avoirdupois	1·772 grams	0·248 4637
1 ounce avoirdupois	28·350 grams	1·452 5561
1 pound (16 oz.)	= 453·59243 grams	2·656 6658
1 stone (14 lb.)	6·350 kilogram	0·802 7737
1 quarter (28 lb.)	12·70 kilograms	1·103 8037
1 cwt. (112 lb.)	= 50·80 kilograms	1·705 8637
,,	= 0·5080 quintal	1·705 8637
1 ton*(20 cwt.)	= 1016·0 kilograms	3·006 8937

Grains.	Gram.	Ounces (Av.)	Grams.
1 =	0·06480	1	28·35
2	0·12960	2 =	56·70
3 =	0·19440	3 =	85·05
4	0·25920	4 =	113·40
5	0·32399	5 =	141·75
6	0·38879	6 =	170·10
7 =	0·45359	7 =	198·45
8 =	0·51839	8 =	226·80
9 =	0·58319	9	255·15

44 kilograms = 97 pounds within 0·001 lb. in excess.
303 ,, = 668 ,, ,, 0·0006 lb. ,,

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* The “short ton” (2000 lb.) is occasionally used both in this country and in America. In contradistinction the ton of 2240 lb. is called the “long ton.”

WEIGHTS AND MEASURES—*continued.*

Pounds to Kilograms.	Hundredweights to Kilograms
1 = 0·45359	1 = 50·8
2 = 0·90718	2 = 101·6
3 = 1·36077	3 = 152·4
4 = 1·81436	4 = 203·2
5 = 2·26795	5 = 254·0
6 = 2·72154	6 = 304·8
7 = 3·17513	7 = 355·6
8 = 3·62872	8 = 406·4
9 = 4·08231	9 = 457·2

Ex. How many grams are equivalent to 39 ounces (av.)?

30 = 850·5
9 = 255·15

1105·65 grams.

BRITISH AND UNITED STATES WEIGHTS AND MEASURES.

British.	United States.
Standard yard at 62° F	standard yard at 59·6° F
1 lb.	1 lb.
1 gallon	1·2 gallon.
5/6 ,,	= 1 ,, (= 3·7883 litres).

cubic feet = 7·4733 U.S. gallons.
cubic inches = 0·00433 ,,

In the drug trade two large bottles are used:

Corbyn 40 fluid oz. (quart).
Winchester quart 80 ,, (½ gallon).

85 minims = 5 c.c. = 1 teaspoonful.
255 ,, = 15 c.c. = 1 tablespoonful.

FOREIGN WEIGHTS AND THEIR ENGLISH EQUIVALENTS.

The Metric System is compulsory in Austria, Belgium, France, Germany, Greece, Italy, Luxemburg, the Netherlands, Portugal, Roumania, Spain, Switzerland, Turkey, and most of the South American Republics; optional in Great Britain, the United States, and Russia.

China .	Tael weight	1·33 oz.		
	Catty	16 tael 1·33 lb.		
	Picul	133·33 lb.		
Egypt .	Oke	2·[illegible]6 lb.		
	78 okes	100 kilos.		
	Cantar	124·36 lb.		
Japan	Liquid koka	39·705[illegible] gallons.		
	„ sho	1·5881 quarts		
	Dry koka	4·9626 bushels		
	„ sho	0·1985 pecks.		
	Kwan	8·2673 lb.		
	Kin	1·3228 lb.		
Russia .	Funt	0·9 British lb.		
	40 funt	1 pood 36·11 lb.		
Turkey	Oke	400 drams 2·836 lb.		
	Kantar	124·36 lb.		
	78 okes	100 kilos 220·46 lb.		
Greece	1 ocque	2·84 lb.	1 livre	1·1 lb.
	1 quintal	132·2 lb.	1 drachme	0·11 oz.

TABLE SHOWING THE SIGNS USED IN WRITING MEDICAL PRESCRIPTIONS.

½ grain . .	½ gr.	1 drachm . .	ʒ i, or ʒ j.
1 „ . .	gr. j, or gr. i.	1½ „ . .	ʒ iss.
1½ „ . .	gr. iss.	2 drachms . .	ʒ ii, or ʒ ij.
2 grains	gr. ii, or gr. ij.	3 „ .	ʒ iii, or ʒ iij.
2½ „ . .	gr. iiss.	3½ „ .	ʒ iiiss.
4 „ . .	gr. iv.	7½ „ . .	ʒ viiss.
8 „ . .	gr. viii, or gr. viij.	½ ounce .	℥ ss.
½ scruple .	℈ ss.	1 „ . .	℥ i, or ℥ j.
1 „ .	℈ i, or ℈ j.	1½ „ . .	℥ iss.
1½ „ .	℈ iss.	½ pint	Oss.
2 scruples	℈ ii, or ℈ ij.	1 „	O.

Densities of Elements and Common Substances
(Liquids at 15° C.)

Agate	2·6
Aluminium	2·7
Aluminium bronze	8
Amber	1·1
Amphibole	2·9 3·1
Anhydrite	2·98
Anthracite	1·35 1·7
Antimony	6·62
Apatite	3·3
Arragonite	3
Arsenic	5·73
Ash	0·6 ·8
Bamboo	0·4
Basalt	2·8
[illegible] wood	0·69 ·8
Beeswax	0·96
Bismuth	9·8
Bitumen	0·8 1·2
Box-wood	0·9 1·1
Bone	1·8 2
Brass	8·4 8·7
Brick	2·1
Bromine	3·1
Bronze coinage	8·66
Cadmium	8·64
Calamine	3·4
Calc-spar	2·7
Cedar	0·5 ·6
Celluloid	1·4
Chalk (mean)	2·3
Charcoal (wood)	0·3-·5
Chloroform	1·5
Chrome alum	1·83
Chromium	6·5
Cinnabar	8·1
Coal	1·2-1·5
Cobalt	8·6
Coke	1·0 1·7
Copper	8·93
Cork	0·22-·26
Diamond	3·52
Dolomite	2·9
Ebonite	1·8
Ebony	1·2
Elm (dry)	0·59
Emery	4
Felspar	2·4 2·6
Fir (Riga) dry	0·75
Fluor spar	3·2
Galena	7·6
Gas carbon	1·9
German silver	8·5-8·9
Glass (crown)	2·5
,, (flint)	2·9 3·25
,, (Bohemian)	2·4
Glycerin	1·26
Gold	19·32
,, (18 carat)	14·88
,, coinage (British)	17·18*
Granite	2·5 3
Graphite	2·3
Gun metal	8 8·4
Gutta percha	0·97
Gypsum	2·3
Heavy spar	4·5
Haematite	5
Ice (at 0°)	0·9168
Iceland Spar	2·7
India rubber	0·91-·93
Iodine	4·95
Iron (cast)	7·1-7·7
,, (wrought)	7·8-7·9

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* These values were kindly supplied to the author by Dr. T. K. Rose, Chemist to the Royal Mint.

Ivory	1·8–1·9
Lead	11·37
Lime	3·2
Lithium	0·534
Magnesium	1·74
Mahogany	·56–·85
Manganese	7·39
Marble	2·5–2·8
Mercury	13·56
Methylated spirit	0·83
Mica	2·7–3·1
Milk (cows')	1·03
Molybdenum	10·0
Nickel	8·9
Oak (English)	0·93
Osmium	22·5
Palladium	11·4
Petrol	0·68–·72
Phosphor bronze	8·7–8·9
Phosphorus (yellow)	1·84
" (red)	2·2
Pine-wood	0·56
Platinum	21·5
Potassium	0·862
Pumice-stone	0·4–·9
Pyrites (iron)	5
Pyrolusite	4·9
Quartz	2·66
Sand (silver)	2·63
Sea-water	1·026
Selenite	2·3
Serpentine	2·6
Shale	2·5
Silica (fused):—	
" (transparent)	2·21
" (translucent)	2·07
Silicon	2·3
Silver	10·5
" coinage (British)	10·35–10·38*
Slate	2·1–2·8
Sodium	0·97
Spermaceti	0·94
Steel	7·7–7·9
Strontianite	3·6
Strontium	2·54
Sugar (cane)	1·6
Sulphur (rhombic)	2·07
Talc	2·5
Teak (Indian)	0·7–·9
Tin	7·29
Tinstone	6·9
Turpentine	0·87
Vanadium	5·5
Willow-wood	0·4
Witherite	4·3
Wool	1·6
Zinc	7·1
Zinc blende	4·16

* These values were kindly supplied to the author by Dr. T. K. Rose, Chemist t the Royal Mint.

TABLE FOR THE CONVERSION OF DRAMS PER LB. INTO PERCENTAGE AND INTO LB PER TON.

Drams per lb. (av.)	Per cent.	Lb. per ton (2240 lb.).	Drams per lb. (av.)	Per cent.	Lb. per ton (2240 lb.).
¼	0·097656 (or 0·1 nearly)	2·187494	3¾	1·465	32·81
			4	1·562	35·00
½	·195	4·37	4¼	1·660	37·19
¾	·293	6·56	4½	1·758	39·38
1	·390625 *	8·75 †	4¾	1·855	41·56
1¼	·488	10·94	5	1·953	43·75
1½	·586	13·12	10	3·906	87·50
1¾	·683	15·31	15	5·859	131·25
2	·781	17·50	20	7·812	175·00
2¼	·879	19·68	25	9·765	218·75
2½	·976	21·87	30	11·719	262·50
2¾	1·074	24·06	35	13·672	306·25
3	1·172	26·25	40	15·625	350·00
3¼	1·269	28·43	45	17·578	393·75
3½	1·367	30·62	50	19·531	437·50

* Log. $\bar{1}$·59176.

† Log. 0·94200.

TABLE FOR THE CONVERSION OF PERCENTAGE INTO CWTS., QRS., AND LB. PER TON, AND INTO QRS. AND LB. PER CWT.

Per cent	Per ton.			Per cwt.		Per cent.	Per ton.			Per cwt.	
	cwt.	qrs.	lb	qrs.	lb.		cwt.	qrs.	lb	qrs.	lb.
1	..	..	22·4	..	1·12	51	10	..	22·4	2	1·12
2	..	1	16·8	..	2·24	52	10	1	16·8	2	2·24
3	..	2	11·2		3·36	53	10	2	11·2	2	3·36
4	..	3	5·6	..	4·48	54	10	3	5·6	2	4·48
5	1	..		..	5·60	55	11	..		2	5·60
6	1	..	22·4	..	6·72	56	11	..	22·4	2	6·72
7	1	1	16·8		7·84	57	11	1	16·8	2	7·84
8	1	2	11·2		8·96	58	11	2	11·2	2	8·96
9	1	3	5·6		10·08	59	11	3	5·6	2	10·08
10	2	..	..		11·20	60	12	..		2	11·20
11	2	..	22·4		12·32	61	12	..	22·4	2	12·32
12	2	1	16·8		13·44	62	12	1	16·8	2	13·44
13	2	2	11·2		14·56	63	12	2	11·2	2	14·56
14	2	3	5·6		15·68	64	12	3	5·6	2	15·68
15	3	..	..		16·8	65	13	..	..	2	16·8
16	3	..	22·4		17·92	66	13	..	22·4	2	17·92
17	3	1	16·8		19·04	67	13	1	16·8	2	19·04
18	3	2	11·2	..	20·16	68	13	2	11·2	2	20·16
19	3	3	5·6		21·28	69	13	3	5·6	2	21·28
20	4	..	..	..	22·40	70	14	..	..	2	22·40
21	4	..	22·4		23·52	71	14	..	22·4	2	23·52
22	4	1	16·8	..	24·64	72	14	1	16·8	2	24·64
23	4	2	11·2		25·76	73	14	2	11·2	2	25·76
24	4	3	5·6		26·88	74	14	3	5·6	2	26·88
25	5	..		1		75	15	..	..	3	
26	5	..	22·4	1	1·12	76	15	..	22·4	3	1·12
27	5	1	16·8	1	2·24	77	15	1	16·8	3	2·24
28	5	2	11·2	1	3·36	78	15	2	11·2	3	3·36
29	5	3	5·6	1	4·48	79	15	3	5·6	3	4·48
30	6	..	..	1	5·60	80	16	..	..	3	5·60
31	6	..	22·4	1	6·72	81	16	..	22·4	3	6·72
32	6	1	16·8	1	7·84	82	16	1	16·8	3	7·84
33	6	2	11·2	1	8·96	83	16	2	11·2	3	8·96
34	6	3	5·6	1	10·08	84	16	3	5·6	3	10·08
35	7	..	..	1	11·20	85	17	..	..	3	11·20
36	7	..	22·4	1	12·32	86	17	..	22·4	3	12·32
37	7	1	16·8	1	13·44	87	17	1	16·8	3	13·44
38	7	2	11·2	1	14·56	88	17	2	11·2	3	14·56
39	7	3	5·6	1	15·68	89	17	3	5·6	3	15·68
40	8	..	..	1	16·8	90	18	..	..	3	16·8
41	8	..	22·4	1	17·92	91	18	..	22·4	3	17·92
42	8	1	16·8	1	19·04	92	18	1	16·8	3	19·04
43	8	2	11·2	1	20·16	93	18	2	11·2	3	20·16
44	8	3	5·6	1	21·28	94	18	3	5·6	3	21·28
45	9	..	..	1	22·40	95	19	..	..	3	22·40
46	9	..	22·4	1	23·52	96	19	..	22·4	3	23·52
47	9	1	16·8	1	24·64	97	19	1	16·8	3	24·64
48	9	2	11·2	1	25·76	98	19	2	11·2	3	25·76
49	9	3	5·6	1	26·88	99	19	3	5·6	3	26·88
50	10	..	..	2	..	100	20	..	..	4	..

Per cent.	·1	·2	·3	·4	·5	·6	·7	·8	·9
lb. per cwt.	·112	·224	·336	·448	·56	·672	·784	·896	1·008
lb. per ton	2·24	4·48	6·72	8·96	11·2	13·44	15·68	17·92	20·16

THE BAROMETER.

I. *Inches into Millimetres.*

Inches	Millimetres.	Inches.	Millimetres.	Inches.	Millimetres.	Inches.	Millimetres.
27·5	698·49	28·4	721·35	29·3	744·21	30·2	767·07
·6	701·03	·5	723·89	·4	746·75	·3	769·61
·7	703·57	·6	726·43	·5	749·29	·4	772·15
·8	706·11	·7	728·97	·6	751·83	·5	774·69
·9	708·65	·8	731·51	·7	754·37	·6	777·23
28·0	711·19	·9	734·05	·8	756·91	·7	779·77
·1	713·73	29·0	736·59	·9	759·45	·8	782·31
·2	716·27	·1	739·13	30·0	761·99	·9	784·85
·3	718·81	·2	741·67	·1	764·53		

Inches.	·01	·02	·03	·04	·05	·06	·07	·08	·09
Millimetres,	·25	·51	·76	1·02	1·27	1·52	1·78	2·03	2·29

II. *Millimetres into Inches.*

Mm.	Inches	Mm	Inches	Mm.	Inches	Mm	Inches.	Mm.	Inches.
700	27·56	718	28·27	735	28·94	752	29·61	769	30·28
701	·60	719	·31	736	·98	753	·65	770	·32
702	·64	720	·35	737	29·02	754	·69	771	·36
703	·68	721	·39	738	·06	755	·73	772	·39
704	·72	722	·43	739	·10	756	·76	773	·43
705	·76	723	·47	740	·13	757	·80	774	·47
706	·80	724	·50	741	·17	758	·84	775	·51
707	·84	725	·54	742	·21	759	·88	776	·55
708	·88	726	·58	743	·25	760	·92	777	·59
709	·91	727	·62	744	·29	761	·96	778	·63
710	·95	728	·66	745	·33	762	30·00	779	·67
711	·99	729	·70	746	·37	763	·04	780	·71
712	28·03	730	·74	747	·41	764	·08	781	·75
713	·07	731	·78	748	·45	765	·12	782	·79
714	·11	732	·82	749	·49	766	·16	783	·83
715	·15	733	·86	750	·53	767	·20	784	·87
716	·19	734	·90	751	·57	768	·24	785	·91
717	·23								

TABLE FOR CORRECTION OF VOLUMES OF GASES FOR TEMPERATURE, GIVING THE DIVISOR FOR THE FORMULA.

$$V^1 = \frac{V \times B'}{760 \times (1 + \delta t)} \qquad \delta = \cdot 003665$$

t	760 × (1 + δt).	Log. [760 × (1 + δt)].	t	760 × (1 + δt)	Log [760 × (1 + δt)]
° C.			° C.		
0·0	760·0000	2·8808136	4·0	771·1416	2·8871341
·1	760·2785	9727	·1	771·4201	2909
·2	760·5571	2·8811318	·2	771·6987	4477
·3	760·8356	2908	·3	771·9772	6045
·4	761·1142	4498	·4	772·2558	7612
0·5	761·3927	6087	4·5	772·5343	9178
·6	761·6712	7675	·6	772·8128	2·8880743
·7	761·9498	9263	·7	773·0914	2308
·8	762·2283	2·8820850	·8	773·3699	3872
·9	762·5069	2437	·9	773·6485	5436
1·0	762·7854	2·8824024	5·0	773·9270	2·8887000
·1	763·0639	5610	·1	774·2055	8563
·2	763·3425	7195	·2	774·4841	2·8890125
·3	763·6210	8779	·3	774·7626	1687
·4	763·8996	2·8830363	·4	775·0412	3248
1·5	764·1781	1946	5·5	775·3197	4808
·6	764·4566	3528	·6	775·5982	6368
·7	764·7352	5111	·7	775·8768	7927
·8	765·0137	6692	·8	776·1553	9486
·9	765·2923	8273	·9	776·4339	2·8901044
2·0	765·5708	2·8839854	6·0	776·7124	2·8902602
·1	765·8493	2·8841434	·1	776·9909	4159
·2	766·1279	3013	·2	777·2695	5716
·3	766·4064	4591	·3	777·5480	7272
·4	766·6850	6169	·4	777·8266	8828
2·5	766·9635	7747	6·5	778·1051	2·8910383
·6	767·2420	2·8849324	·6	778·3836	1938
·7	767·5206	2·8850901	·7	778·6622	3492
·8	767·7991	2477	·8	778·9407	5045
·9	768·0777	4052	·9	779·2193	6597
3·0	768·3562	2·8855626	7·0	779·4978	2·8918149
·1	768·6347	7199	·1	779·7763	9701
·2	768·9133	8772	·2	780·0549	2·8921252
·3	769·1918	2·8860345	·3	780·3334	2802
·4	769·4704	1918	·4	780·6120	4352
3·5	769·7489	3490	7·5	780·8905	5901
·6	770·0274	5062	·6	781·1690	7450
·7	770·3060	6633	·7	781·4476	8998
·8	770·5845	8203	·8	781·7261	2·8930546
·9	770·8631	9772	·9	782·0047	2093

TABLE FOR CORRECTION OF VOLUMES OF GASES—*continued.*

t	760 × (1 + δt).	Log. [760 × (1 + δt)].	t	760 × (1 + δt).	Log. [760 × (1 + δt)].
° C.			° C.		
8·0	782·2832	2·8933640	12·5	794·8175	2·9002674
·1	782·5617	5186	·6	795·0960	4196
·2	782·8403	6732	·7	795·3746	5717
·3	783·1188	8277	·8	795·6531	7238
·4	783·3974	9821	·9	795·9317	8758
8·5	783·6759	2·8941365	13·0	796·2102	2·9010277
·6	783·9544	2908	·1	796·4887	1796
·7	784·2330	4451	·2	796·7673	3315
·8	784·5115	5993	·3	797·0458	4833
·9	784·7901	7535	·4	797·3244	6350
9·0	785·0686	2·8949076	13·5	797·6029	7867
·1	785·3471	2·8950617	·6	797·8814	9384
·2	785·6257	2157	·7	798·1600	2·9020900
·3	785·9042	3697	·8	798·4385	2415
·4	786·1828	5236	·9	798·7171	3930
9·5	786·4613	6774	14·0	798·9956	2·9025444
·6	786·7398	8311	·1	799·2741	6957
·7	787·0184	9848	·2	799·5527	8470
·8	787·2969	2·8961385	·3	799·8312	9983
·9	787·5755	2921	·4	800·1098	2·9031495
10·0	787·8540	2·8964457	14·5	800·3883	2·9033007
·1	788·1325	5993	·6	800·6668	4518
·2	788·4111	7528	·7	800·9454	6029
·3	788·6896	9062	·8	801·2239	7539
·4	788·9682	2·8970595	·9	801·5025	9049
10·5	789·2467	2128	15·0	801·7810	2·9040558
·6	789·5252	3660	·1	802·0595	2066
·7	789·8038	5192	·2	802·3381	3574
·8	790·0823	6723	·3	802·6166	5081
·9	790·3609	8254	·4	802·8952	6588
11·0	790·6394	2·8979784	15·5	803·1737	8095
·1	790·9179	2·8981314	·6	803·4522	9601
·2	791·1965	2843	·7	803·7308	2·9051106
·3	791·4750	4372	·8	804·0093	2611
·4	791·7536	2·8985900	·9	804·2879	4115
11·5	792·0321	7428	16·0	804·5664	2·9055619
·6	792·3106	8955	·1	804·8449	7122
·7	792·5892	2·8990482	·2	805·1235	8625
·8	792·8677	2008	·3	805·4020	2·9060127
·9	793·1463	3533	·4	805·6806	1628
12·0	793·4248	2·8995058	16·5	805·9591	2·9063129
·1	793·7033	6582	·6	806·2376	4630
·2	793·9819	8106	·7	806·5162	6130
·3	794·2604	9629	·8	806·7947	7630
·4	794·5390	2·9001152	·9	807·0733	9129

TABLE FOR CORRECTION OF VOLUMES OF GASES—*continued.*

t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.	t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.
° C.			° C.		
17·0	807·3518	2·9070628	21·5	819·8861	2·9137535
·1	807·6303	2126	·6	820·1646	9010
·2	807·9089	3624	·7	820·4432	2·9140485
·3	808·1874	5121	·8	820·7217	1960
·4	808·4660	6618	·9	821·0003	3434
17·5	808·7445	8114	22·0	821·2788	2·9144907
·6	809·0230	2·9079609	·1	821·5573	6380
·7	809·3016	2·9081104	·2	821·8359	7852
·8	809·5801	2598	·3	822·1144	9323
·9	809·8587	4092	·4	822·3930	2·9150794
18·0	810·1372	2·9085586	22·5	822·6715	2265
·1	810·4175	7079	·6	822·9500	3735
·2	810·6943	8571	·7	823·2286	5205
·3	810·9728	2·9090063	·8	823·5071	6674
·4	811·2514	1554	·9	823·7857	8143
18·5	811·5299	3045	23·0	824·0642	2·9159611
·6	811·8084	4535	·1	824·3427	2·9161079
·7	812·0870	6025	·2	824·6213	2546
·8	812·3655	7515	·3	824·8998	4013
·9	812·6441	9004	·4	825·1784	5479
19·0	812·9226	2·9100492	23·5	825·4569	6945
·1	813·2011	1980	·6	825·7354	8410
·2	813·4797	3467	·7	826·0140	9875
·3	813·7582	4954	·8	826·2925	2·9171339
·4	814·0368	6440	·9	826·5711	2802
19·5	814·3153	7926	24·0	826·8496	2·9174265
·6	814·5938	9411	·1	827·1281	5728
·7	814·8724	2·9110896	·2	827·4067	7190
·8	815·1509	2380	·3	827·6852	8652
·9	815·4295	3864	·4	827·9638	2·9180114
20·0	815·7080	2·9115347	24·5	828·2423	1575
·1	815·9865	6830	·6	828·5208	3035
·2	816·2651	8312	·7	828·7994	4495
·3	816·5436	9794	·8	829·0779	5954
·4	816·8222	2·9121275	·9	829·3565	7412
20·5	817·1007	2756	25·0	829·6350	2·9188870
·6	817·3792	4236	·1	829·9135	2·9190328
·7	817·6578	2·9125716	·2	830·1921	1785
·8	817·9363	7195	·3	830·4706	3242
·9	818·2149	8674	·4	830·7492	4699
21·0	818·4934	2·9130152	25·5	831·0277	2·9196155
·1	818·7719	1630	·6	831·3062	7610
·2	819·0505	3107	·7	831·5848	9065
·3	819·3290	4583	·8	831·8633	2·9200520
·4	819·6076	6059	·9	831·1419	1974

TABLE FOR CORRECTION OF VOLUMES OF GASES—*continued.*

t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.	t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.
° C.			° C.		
26·0	832·4201	2·9203427	28·1	838·2697	2·9233838
·1	832·6989	4880	·2	838·5483	5281
·2	832·9775	6333	·3	838·8268	6723
·3	833·2560	7785	·4	839·1054	8165
·4	833·5346	9237	28·5	839·3839	2·9239606
26·5	833·8131	2·9210688	·6	839·6624	2·9241047
·6	834·0916	2139	·7	839·9410	2488
·7	834·3702	3589	·8	840·2195	3928
·8	834·6487	5038	·9	840·4981	5368
·9	834·9273	6487	29·0	840·7766	2·9246807
27·0	835·2058	2·9217936	·1	841·0551	8216
·1	835·4843	9384	·2	841·3337	9684
·2	835·7629	2·9220832	·3	841·6122	2·9251122
·3	836·0414	2279	·4	841·8908	2559
·4	836·3200	3725	29·5	842·1693	3997
27·5	836·5985	5171	·6	842·4478	5431
·6	836·8770	6617	·7	842·7264	6866
·7	837·1556	8062	·8	843·0049	8301
·8	837·4341	9507	·9	843·2835	9736
·9	837·7127	2·9230951	30·0	843·5620	2·9261171
28·0	837·9912	2·9232395			

VAPOUR PRESSURE OF MERCURY.*

Temperature.	Vapour Pressure.	Temperature.	Vapour Pressure.
	mm.		mm.
0° C.	·00016	60	·0246
5	·00026	80	·0885
10	·00043	100	·276
15	·00069	150	2·88
20	·00109	200	17·81
25	·00168	250	75·83
30	·00257	300	248·6
35	·00387	356·7	760
40	·00571	400	1566
50	·0122	450	3229

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* From observations by Ramsay and Young, Callendar and Griffiths, and others (values in mm. of mercury at 0° C.).

VOLUME AND DENSITY OF WATER AT DIFFERENT TEMPERATURES.*

Temp.	Sp. gr. of Water (at 0° = 1).	Vol. of Water (at 0° = 1).	Sp. gr. of Water (at 4° = 1).*	Vol. of Water (at 4° = 1).
0°	1·000000	1·000000	·999871	1·000129
1	1·000057	0·999943	·999928	1·000072
2	1·000098	·999902	·999969	1·000031
3	1·000120	·999880	·999991	1·000009
4	1·000129	·999871	1·000000	1·000000
5	1·000119	·999881	0·999990	1·000010
6	1·000099	·999901	·999970	1·000030
7	1·000062	·999938	·999933	1·000067
8	1·000015	·999985	·999886	1·000114
9	0·999953	1·000017	·999821	1·000176
10	·999876	1·000124	·999747	1·000253
11	·999784	1·000216	·999655	1·000345
12	·999678	1·000322	·999549	1·000451
13	·999559	1·000441	·999430	1·000570
14	·999429	1·000572	·999299	1·000701
15	·999289	1·000712	·999160	1·000841
16	·999131	1·000870	·999002	1·000999
17	·998970	1·001031	·998841	1·001160
18	·998782	1·001219	·998654	1·001348
19	·998588	1·001413	·998460	1·001542
20	·998388	1·001615	·998259	1·001744
21	·998176	1·001828	·998047	1,001957
22	·997953	1·002049	·997826	1·002177
23	·997730	1·002276	·997601	1·002405
24	·997495	1·002511	·997367	1·002641
25	·997249	1·002759	·997120	1·002888
26	·996994	1·003014	·996866	1·003144
27	·996732	1·003278	·996603	1·003408
28	·996460	1·003553	·996331	1·003682
29	996179	1·003835	·996051	1·003965
30	·995894	1·004123	·995765	1·004253
35	0·99431	1·00572	0·99418	1·00593
40	0·99218	1·00754	0·99235	1·00773
45	0·99050	1·00958	0·99037	1·00974
50	0·98832	1·01182	0·98819	1·01201
55	0·98594	1·01426	0·98581	1·01442
60	0·98350	1·01678	0·98338	1·01697
65	0·98086	1·01951	0·98074	1·01971
70	0·97807	1·02243	0·97794	1·02260
75	0·97511	1·02553	0·97498	1·02569
80	0·97206	1·02874	0·97194	1·02890
85	0·96892	1·03207	0·96879	1·03224
90	0·96568	1·03554	0·96556	1·03574
95	0·96231	1·03918	0·96219	1·03938
100	0·95879	1·04299	0·95866	1·04315

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* This table may be utilized to reduce a sp. gr. taken with reference to water at one temperature to water at 4° C. Thus, let S_{15} be the sp. gr. of a substance referred to water at 15° C. as unity, then the sp. gr. (S_4) referred to water at 4° as unity will be $S_4 = S_{15} \times {\cdot}99916 - S_{15}(1 - {\cdot}00084)$.

* Rosetti.

BAUMÉ'S HYDROMETER. *Table for Liquids heavier than Water.**

° B.	° Tw.	Sp. gr.	° B.	° Tw.	Sp. gr.	° B.	° Tw.	Sp. gr.
1	1·4	1·007	23	38	1·190	45	90·6	1·453
2	2·8	1·014	24	40	1·200	46	93·6	1·468
3	4·4	1·022	25	42	1·210	47	96·6	1·483
4	5·8	1·029	26	44	1·220	48	99·6	1·498
5	7·4	1·037	27	46·2	1·231	49	103	1·515
6	9	1·045	28	48·2	1·241	50	106	1·530
7	10·2	1·052	29	50·4	1·252	51	109·2	1·546
8	12	1·060	30	52·6	1·263	52	112·6	1·563
9	13·4	1·067	31	54·8	1·274	53	116	1·580
10	15	1·075	32	57	1·285	54	119·4	1·597
11	16·6	1·083	33	59·4	1·297	55	123	1·615
12	18·2	1·091	34	61·6	1·308	56	127	1·635
13	20	1·100	35	64	1·320	57	130·4	1·652
14	21·6	1·108	36	66·4	1·332	58	134·2	1·671
15	23·2	1·116	37	69	1·345	59	138·2	1·691
16	25	1·125	38	71·4	1·357	60	142	1·710
17	26·8	1·134	39	74	1·370	61	146·4	1·732
18	28·4	1·142	40	76·6	1·383	62	150·6	1·753
19	30·4	1·152	41	79·4	1·397	63	155	1·775
20	32·4	1·162	42	82	1·410	64	159	1·795
21	34·2	1·171	43	84·8	1·424	65	164	1·820
22	36	1·180	44	87·6	1·438	66	168·4	1·842

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* This is the Baumé's hydrometer mostly used on the Continent of Europe, but other scales are in use there as well, and quite another scale for Baumé's hydrometer is used in America (Lunge, *Technical Chemists' Handbook*).

Table for Liquids lighter than Water.

° B.	Sp. gr.	° B.	Sp. gr.	° B.	Sp. gr.
10	1·000	27	0·896	44	0·811
11	0·993	28	0·890	45	0·807
12	0·986	29	0·885	46	0·802
13	0·980	30	0·880	47	0·798
14	0·973	31	0·874	48	0·794
15	0·967	32	0·869	49	0·789
16	0·960	33	0·864	50	0·785
17	0·954	34	0·859	51	0·781
18	0·948	35	0·854	52	0·777
19	0·942	36	0·849	53	0·773
20	0·936	37	0·844	54	0·768
21	0·930	38	0·839	55	0·764
22	0·924	39	0·834	56	0·760
23	0·918	40	0·830	57	0·757
24	0·913	41	0·825	58	0·753
25	0·907	42	0·820	59	0·749
26	0·901	43	0·816	60	0·745

Twaddell's Hydrometer.—To convert degrees Twaddell into specific gravity (water = 1000): multiply the number by 5, and add 1000 to the product.

To reduce specific gravity (water = 1000) to Twaddell: deduct 1000, and divide the remainder by 5.

TABLE SHOWING THE STRENGTH OF HYDROCHLORIC ACID OF DIFFERENT DENSITIES. (Lange and Marchlewski.)

Sp. gr. at 15° C./4°.	HCl per cent.	Grams HCl per litre.	Sp. gr. at 15° C./4°.	HCl per cent.	Grams HCl per litre.	Sp. gr. at 15° C./4°.	HCl per cent.	Grams HCl per litre.
1·005	1·15	12	1·075	15·16	163	1·140	27·66	315
1·010	2·14	22	1·080	16·15	174	1·145	28·61	328
1·015	3·12	32	1·085	17·13	186	1·150	29·57	340
1·020	4·13	42	1·090	18·11	197	1·155	30·55	353
1·025	5·15	53	1·095	19·06	209	1·160	31·52	366
1·030	6·15	64	1·100	20·01	220	1·165	32·49	379
1·035	7·15	74	1·105	20·97	232	1·170	33·46	392
1·040	8·16	85	1·110	21·92	243	1·175	34·42	404
1·045	9·16	96	1·115	22·86	255	1·180	35·39	418
1·050	10·17	107	1·120	23·82	267	1·185	36·31	430
1·055	11·18	118	1·125	24·78	278	1·190	37·23	443
1·060	12·19	129	1·130	25·75	291	1·195	38·16	456
1·065	13·19	141	1·135	26·70	303	1·200	39·11	469
1·070	14·17	152						

TABLE SHOWING THE STRENGTHS OF NITRIC ACID OF DIFFERENT DENSITIES. (Lange and Rey.)

Sp. gr. at 15°/4°.	HNO_3 per cent.	Sp. gr. at 15°/4°.	HNO_3 per cent.	Sp. gr. at 15°/4°.	HNO_3 per cent.
1·020	3·70	1·220	35·28	1·420	69·80
1·030	5·50	1·230	36·78	1·430	72·17
1·040	7·26	1·240	38·29	1·440	74·68
1·050	8·99	1·250	39·82	1·450	77·28
1·060	10·68	1·260	41·34	1·460	79·98
1·070	12·33	1·270	42·87	1·470	82·90
1·080	13·95	1·280	44·41	1·480	86·05
1·090	15·53	1·290	45·95	1·490	89·60
1·100	17·11	1·300	47·49	1·500	94·09
1·110	18·67	1·310	49·07	1·502	95·08
1·120	20·23	1·320	50·71	1·504	96·00
1·130	21·77	1·330	52·37	1·506	96·76
1·140	23·31	1·340	54·07	1·508	97·50
1·150	24·84	1·350	55·79	1·510	98·10
1·160	26·36	1·360	57·57	1·512	98·53
1·170	27·88	1·370	59·39	1·514	98·90
1·180	29·38	1·380	61·27	1·516	99·21
1·190	30·88	1·390	63·23	1·518	99·46
1·200	32·36	1·400	65·30	1·520	99·67
1·210	33·82	1·410	67·50		

Note. To get N_2O_5 subtract one-seventh from the percentage of nitric acid Thus, 1·450 sp. gr. 77·28 − 11·04 = 66·24% N_2O_5.

The figures refer to *chemically pure* nitric acid; commercial acid, containing nitrous acid, etc., contains less real HNO_3 at the same density.

* V. Veley and Manley have given (see *Jour. Soc. Chem. Ind.*, 1903, pp. 1227-1229) a table of densities of nitric acid from 1·285 to 1·521, the results of which agree closely with those tabulated above.

*Corrections for 1° C. (Add when above 15°, subtract when below 15° C.).

Sp. gr.	Correction.	Sp. gr.	Correction.
1·020 1·040	0·0002	1·281 1·310	0·0010
1·041 1·070	0·0003	1·311-1·350	0·0011
1·071 1·100	0·0004	1·351 1·365	0·0012
1·101 1·130	0·0005	1·366 1·400	0·0013
1·131-1·160	0·0006	1·401 1·435	0·0014
1·161-1·200	0·0007	1·436-1·490	0·0015
1·201 1·245	0·0008	1·491 1·500	0·0016
1·246 1·280	0·0009	1·501 1·520	0·0017

Table Showing the Strength of Sulphuric Acid of Different Densities.*

Sp. gr. at 15°/4° C.	SO_3 per cent	H_2SO_4 per cent.	Grams H_2SO_4 per litre.	Sp. gr. at 15°/4° C.	SO_3 per cent	H_2SO_4 per cent.	Grams H_2SO_4 per litre.
1·010	1·28	1·57	16	1·340	35·71	43·74	586
1·020	2·47	3·03	31	1·350	36·58	44·82	605
1·030	3·67	4·49	46	1·360	37·45	45·88	624
1·040	4·87	5·96	62	1·370	38·32	46·94	643
1·050	6·02	7·37	77	1·380	39·18	48·00	662
1·060	7·16	8·77	93	1·390	40·05	49·06	682
1·070	8·32	10·19	109	1·400	40·91	50·11	702
1·080	9·47	11·60	125	1·410	41·76	51·15	721
1·090	10·60	12·99	142	1·420	42·57	52·15	740
1·100	11·71	14·35	158	1·430	43·36	53·11	759
1·110	12·82	15·71	175	1·440	44·11	54·07	779
1·120	13·89	17·01	191	1·450	44·92	55·03	798
1·130	14·95	18·31	207	1·460	45·69	55·97	817
1·140	16·01	19·61	223	1·470	46·45	56·90	837
1·150	17·07	20·91	239	1·480	47·21	57·83	856
1·160	18·11	22·19	257	1·490	47·95	58·74	876
1·170	19·16	23·47	275	1·500	48·73	59·70	896
1·180	20·21	24·76	292	1·510	49·51	60·65	916
1·190	21·26	26·04	310	1·520	50·28	61·59	936
1·200	22·30	27·32	328	1·530	51·04	62·53	957
1·210	23·33	28·58	346	1·540	51·78	63·43	977
1·220	24·36	29·84	364	1·550	52·46	64·26	996
1·230	25·39	31·11	382	1·560	53·22	65·20	1017
1·240	26·35	32·28	400	1·570	53·95	66·09	1038
1·250	27·29	33·43	418	1·580	54·65	66·95	1058
1·260	28·22	34·57	435	1·590	55·37	67·83	1078
1·270	29·15	35·71	454	1·600	56·09	68·70	1099
1·280	30·10	36·87	472	1·610	56·79	69·56	1120
1·290	31·04	38·03	490	1·620	57·49	70·42	1141
1·300	31·99	39·19	510	1·630	58·18	71·27	1162
1·310	32·94	40·35	529	1·640	58·88	72·12	1182
1·320	33·88	41·50	548	1·650	59·57	72·96	1204
1·330	34·80	42·66	567	1·660	60·26	73·81	1225

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* The above table is taken from Lunge's *Technical Chemists' Handbook* (second edition, 1916) and embodies his latest corrections. It differs in parts from the former table by Lunge, Isler and Naef.

TABLE SHOWING THE STRENGTH OF SULPHURIC ACID OF DIFFERENT DENSITIES—*continued*.

Sp. gr. at 15°/4° C.	SO_3 per cent.	H_2SO_4 per cent.	Grams H_2SO_4 per litre.	Sp. gr. at 15°/4° C.	SO_3 per cent.	H_2SO_4 per cent.	Grams H_2SO_4 per litre.
1·670	60·95	74·66	1216	1·780	68·98	84·50	1504
1·680	61·63	75·50	1268	1·790	69·96	85·70	1534
1·690	62·29	76·30	1289	1·800	70·96	86·92	1565
1·700	63·00	77·17	1312	1·810	72·08	88·30	1598
1·710	63·70	78·04	1334	1·820	73·51	90·05	1639
1·720	64·43	78·92	1357	1·825	74·29	91·00	1661
1·730	65·14	79·80	1381	1·830	75·19	92·10	1685
1·740	65·86	80·68	1404	1·835	76·35	93·56	1717
1·750	66·58	81·56	1427	1·8385	81·08	99·31	1826
1·760	67·30	82·44	1451	1·840	80·59	98·72	1816
1·770	68·17	83·41	1478	1·840	78·01	95·60	1759

Note.—The highest percentages show lower specific gravities than those just below, the maximum being at 99·31 per cent. H_2SO_4. The impurities always present in commercial acid increase its density and consequently cause results deduced from sp. gr. to be unduly high.

CORRECTION FOR 1° C. (ADD WHEN ABOVE 15°, SUBTRACT WHEN BELOW 15° C.)

Sp. gr.	Correction.
1·170 (or less)	0·0006
1·170–1·450	0·0007
1·450–1·580	0·0008
1·580–1·750	0·0009
1·750–1·840	0·0010

SPECIFIC GRAVITIES OF SOLUTIONS OF AMMONIA AT 15° C. (Lunge and Wiernik).*

Specific gravity.	NH_3 per cent.	1 litre at 15° C. contains grams NH_3.	Correction of specific gravity for ± 1° C.
0·880	35·60	313·28	0·00066
·885	33·67	297·98	·000635
·890	31·73	282·40	·00061
·895	30·03	268·77	·000595
·900	28·33	254·97	·00057
·905	26·31	211·09	·000545
·910	24·99	227·41	·00052
·915	23·35	213·65	·000495
·920	21·75	200·10	·00047
·925	20·18	186·67	·000445
·930	18·64	173·35	·00042

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* From Lunge's *Technical Chemists' Handbook* (1916).

SPECIFIC GRAVITIES OF SOLUTIONS OF AMMONIA AT 15° C.—*continued.*

Specific gravity.	NH_3 per cent.	1 litre at 15° C. contains grams NH_3.	Correction of specific gravity for ± 1° C.
·935	17·12	160·07	·00041
·910	15·63	146·92	·00039
·945	14·17	133·91	·000365
·950	12·74	121·05	·00034
·955	11·39	108·11	·000315
·960	9·91	95·12	·00029
·965	8·59	82·89	·000265
·970	7·31	70·91	·00025
·975	6·05	58·93	·00024
·980	4·80	47·03	·00023
·985	3·55	34·97	·00021
·990	2·31	22·87	·00020
·995	1·14	11·34	·00019

SPECIFIC GRAVITIES OF SOLUTIONS OF SODIUM AND POTASSIUM HYDROXIDES AT 15°/4° C.

Sp. gr.	% NaOH.	KOH.	Sp. gr.	NaOH.	KOH.
1·010	0·86	1·18	1·280	25·08	29·00
1·020	1·69	2·28	1·290	25·96	29·96
1·030	2·60	3·36	1·300	26·85	30·91
1·040	3·50	4·44	1·310	27·85	31·84
1·050	4·34	5·53	1·320	28·83	32·78
1·060	5·20	6·60	1·330	29·80	33·70
1·070	6·13	7·68	1·340	30·74	34·63
1·080	7·05	8·76	1·350	31·75	35·55
1·090	7·95	9·82	1·360	32·79	36·46
1·100	8·78	10·87	1·370	33·73	37·37
1·110	9·67	11·92	1·380	34·71	38·28
1·120	10·56	12·96	1·390	35·68	39·18
1·130	11·55	14·01	1·400	36·67	40·09
1·140	12·49	15·04	1·410	37·65	40·98
1·150	13·34	16·08	1·420	38·67	41·87
1·160	14·19	17·10	1·430	39·67	42·76
1·170	15·06	18·13	1·440	40·68	43·63
1·180	16·00	19·15	1·450	41·70	44·50
1·190	16·91	20·17	1·460	42·75	45·37
1·200	17·81	21·17	1·470	43·80	46·23
1·210	18·71	22·16	1·480	44·85	47·09
1·220	19·65	23·17	1·490	45·89	47·93
1·230	20·60	24·14	1·500	46·94	48·78
1·240	21·47	25·13	1·510	48·00	49·61
1·250	22·33	26·10	1·520	49·05	50·48
1·260	23·23	27·07	1·530	50·10	51·32
1·270	24·13	28·04			

The above table is abbreviated from the very full tables given in Lunge's *Technical Chemists' Handbook* (1916). The values given for KOH are calculated from the results obtained by Pickering (*J.C.S.*, 63. 890).

STRENGTH OF SATURATED SOLUTIONS OF A FEW COMMON SALTS.*

	At 60° F.		
	Sp. gr. of saturated solution.	C.c. of water dissolve 1 gram.	Grams in 1 litre of saturated solution
Acid, chromic	1·710	0·59	1075·5
,, citric	1·3026	0·54	861·7
,, tartaric	1·31	0·71	766·1
Alum, ammonia	1·0459	9·95	95·5
,, potash	1·046	9·70	97·7
Ammonium carbonate	1·094	3·94	221·5
,, chloride	1·077	2·8	47[illegible]·4
Borax	1·0205	23·7	41·3
Calcium chloride (anhyd.)	1·4096	1·41	581·6
,, ,, ($CaCl_2,2H_2O$)	1·4096	0·82	771·2
Copper sulphate	1·193	2·79	314·8
Lead acetate	1·2554	2·37	372·5
Magnesium sulphate	1·2755	0·98	643·9
Mercuric chloride	1·0472	17·9	55·4
Potassium acetate	1·406	0·28	1099·2
,, bicarbonate	1·1688	3·21	277·7
,, dichromate	1·066	9·93	97·5
,, bromide	1·3615	1·59	525·7
,, chlorate	1·038	16·53	59·2
,, hydrate	1·553	0·647	942·9
,, iodide	1·7039	0·701	996·4
,, nitrate	1·1152	3·77	240·1
,, permanganate	1·0368	18·7	52·7
,, sulphate	1·0784	9·65	101·3
Sodium bicarbonate	1·0608	11·08	87·8
,, carbonate	1·1608	1·66	436·4
,, chloride	1·201	2·8	316·8
,, phosphate	1·0189	6·91	132·6
,, sulphate	1·1114	2·68	302·7
Zinc sulphate	1·452	0·65	880·0

Note.—In all the above determinations the substances are calculated as of official (*i.e.*, B.P.), not absolute, purity.

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* H. G. Greenish in the *Pharm. Journal*, Dec. 26, 1903.

Glycerin Table.

Per cent Glycerin	Sp. gr. 15° C./15° = 59° F./59°	Sp. gr. 20° C./20° = 68° F./68°	Per cent Glycerin	Sp. gr. 15° C./15°	Per cent Glycerin.	Sp. gr. 15° C./15°.
100	1·26596	1·26348	74	1·19583	40	1·10253
99	1·26335	1·26085	73	1·19309	35	1·08908
98	1·26072	1·25822	72	1·19035	30	1·07564
97	1·25809	1·25560	71	1·18761	25	1·06236
96	1·25517	1·25297	70	1·18487	20	1·04930
95	1·25285	1·25034	69	1·18212	15	1·03652
94	1·25021	1·24771	68	1·17937	10	1·02409
93	1·24756	1·24508	67	1·17662	5	1·01189
92	1·24487	1·24246	66	1·17387		
91	1·24217	1·23983	65	1·17112		
90	1·23945	1·23720	64	1·16837		
89	1·23673	1·23449	63	1·16561		
88	1·23400	1·23178	62	1·16286		Sp. gr. 20° C./20°
87	1·23128	1·22907	61	1·16011		
86	1·22855	1·22636	60	1·15737		
85	1·22583	1·22365	59	1·15462		
84	1·22310	1·22094	58	1·15187		
83	1·22038	1·21823	57	1·14912	70	1·182[illegible]
82	1·21766	1·21552	56	1·14635	60	1·15561
81	1·21493	1·21281	55	1·14362	50	1·12831
80	1·21221	1·21010	54	1·14088	40	1·10118
79	1·20949	1·20737	53	1·13814	30	1·07469
78	1·20677	1·20464	52	1·13539	20	1·04884
77	1·20404	1·20190	51	1·13265	10	1·02391
76	1·20131	1·19917	50	1·12990		
75	1·19857	1·19644	45	1·11618		

The above table is a combination of W. W. J. Nicol's excellent tables for the two temperatures above specified, as given in the *United States Dispensatory*, p. 653, and in Watts's *Dictionary of Chemistry* (most recent edition in each case). In the former work a complete table from 1–100°/₀ glycerin, at 15° C. is given

The following formula is useful :—

$$\frac{\text{sp. gr. of dilute glycerin} - 1{\cdot}000}{{\cdot}002665} = {}^{\circ}/_{\circ} \text{ by weight of glycerin.}$$

The divisor ·00261 is more accurate, however, for mixtures containing between 30 and 60°/₀ glycerin, and ·0025 for those below 30°/₀.

THE PREPARATION OF REAGENTS FOR WATER ANALYSIS.

Nessler's Solution.—First, dissolve 150 grams of stick potash in 150 c.c. of water, and set aside to cool. Next, dissolve 62·5 grams of potassium iodide in about 250 c.c. of water in a 1200 c.c. beaker, transfer about 10 c.c. to a small beaker, and add gradually to the main bulk, with constant stirring, a cold saturated solution of mercuric chloride (of which about 500 c.c. will be required) until a permanent precipitate is obtained. Now add the potassium iodide solution in the small beaker, which should redissolve the precipitate, and continue adding cautiously mercuric chloride until a slight precipitate remains undissolved on stirring. Add the cold potash solution, transfer the whole to a litre flask, make up to the mark with water, and pour into a stoppered bottle. After standing about 12 hours the solution will have become clear, and should then be tested as follows: To 50 c.c. of ammonia-free water add 0·2 c.c. of standard ammonium chloride solution (=0·00001 gram NH_3), mix, and then add 2 c.c. of Nessler's solution, when a yellow tinge should appear *at once* if the latter solution be properly made. If the Nessler's solution is not sensitive—which will be the case if it is perfectly colourless, instead of the proper greenish-yellow tint—a little more mercuric chloride solution should be added, the whole well mixed, allowed to settle, and tested again.

Some Nessler's solutions give a red precipitate when added to water. The art of making a thoroughly satisfactory Nessler's solution can only be acquired by practice.

Alkaline permanganate solution.—Dissolve 200 grams of stick potash in water in a large porcelain dish and add a solution of 8 grams of potassium permanganate in water, using 1100 c.c. altogether. Boil rapidly until concentrated to about 900 c.c., add about 200 c.c. of hot distilled water, and continue boiling till the volume is reduced to a litre. When cool, pour at once into a bottle. Every fresh lot of solution made should be carefully tested before being used.

Standard solution of ammonium chloride.—Dissolve 1·5704 grams of pure dry ammonium chloride in a litre of ammonia-free water; of this take 100 c.c. and make up to a litre with water. Of this latter solution

1 c.c. = 0·00005 gram ammonia.
1·21 c.c. = 0·00005 gram nitrogen.

When 500 c.c. of water are distilled,

1 c.c. = 0·01 part NH_3 per 100,000.
1·21 c.c. = 0·01 part N ,,

The solution should be measured in a standard 1 c.c. pipette divided into hundredths.

Or, by dissolving 1·9094 gm. NH_4Cl in a litre of water, and diluting 100 c.c. of the solution to 1000 c.c., then of this latter solution

1 c.c. = 0·00005 gram ammoniacal nitrogen.

Standard silver nitrate solution. Dissolve 2·4 grams of recryst. silver nitrate in a litre of water and standardize against a solution of pure sodium chloride containing 0·8243 gram per litre (1 c.c. = 0·0005 gram chlorine).

1 c.c. silver nitrate solution = 0·0005 gram Cl,

or when 50 c.c. of water are titrated,

1 c.c. = 1 part combined chlorine per 100,000.

REAGENTS FOR DETERMINATION OF OXYGEN ABSORBED.

(i) *Dilute sulphuric acid.* Add 1 vol. of pure sulphuric acid to 3 vols. of water, and drop in potassium permanganate solution (ii) until the liquid retains a *very faint* pink tint after being kept at 80° F. for four hours.

(ii) *Standard solution of potassium permanganate.* Dissolve 0·395 gram of recryst. potassium permanganate in 1 litre of water.

1 c.c. = 0·0001 gram available oxygen.

(iii) *Potassium iodide solution.* Dissolve 1 part of the pure salt in 10 parts of water.

(iv) *Sodium thiosulphate solution.* Dissolve 1 gram of the crystals in 1 litre of water.

(v) *Starch indicator.* One part of clean potato starch, or arrowroot, is mixed smoothly into an emulsion with cold water, then poured gradually into about 150 or 200 times its weight of boiling water, the boiling continued for a few minutes, then allowed to stand and settle thoroughly. The clear solution only is to be used as the indicator, of which only a few drops are necessary.

Lintner's soluble starch acts well as an indicator, as it gives at once a clear solution in boiling water.

Thresh's starch solution (see p. 95) is also useful as an indicator

REAGENTS REQUIRED FOR DETERMINATION OF HARDNESS.

Preparation of soap solution for Clark's test.—Weigh out 50 grams of commercial oleic acid in a beaker and add 100 c.c. of an alcoholic potash solution made by dissolving 20 grams of stick potash in 180 c.c. of *industrial* methylated spirit, and continue adding the same solution from a burette till a drop of the oleate just gives a red colour with phenol-phthalein spotted on a white tile—about 10 c.c. more being required. Measure the solution and make the volume to 400 c.c. by the addition of methylated spirit. 45 c.c. of the strong soap solution thus obtained are diluted with methylated spirit (2 vols.) and water (1 vol.) to a litre, allowed to stand for about 24 hours, filtered through a double Swedish filter, and standardized against standard calcium chloride solution. The solution will be found to be a little too strong, and is diluted to exact strength, which is attained when 14·25 c.c. are required to form a permanent lather with 50 c.c. of the standard calcium chloride solution.

Standard calcium chloride solution.—Dissolve 0·2 gram of Iceland spar in dilute hydrochloric acid in a platinum dish, adding the acid gradually and having the dish covered with a large watch glass to prevent loss by spirting. When solution has taken place, rinse the glass into the dish, and evaporate to dryness on a water-bath: add water and again evaporate to dryness, and repeat this addition of water and evaporation two or three times in order to ensure complete expulsion of hydrochloric acid. Finally, take up the residue with distilled water, and make up the solution to 1 litre.

50 c.c. correspond to 0·01 gram $CaCO_3$.

TABLES REQUIRED IN WATER ANALYSIS.

1. *Tension of Aqueous Vapour in Millimetres of Mercury from 0° to 35° C.*

° C.	mm.	° C.	mm.	° C.	mm.	° C.	mm.	° C.	mm.
0·0	4·600	2·5	5·491	5·0	6·534	7·5	7·751	10·0	9·165
·1	·633	·6	·530	·1	·580	·6	·804	·1	·227
·2	·667	·7	·569	·2	·625	·7	·857	·2	·288
·3	·700	·8	·608	·3	·671	·8	·910	·3	·350
·4	·733	·9	·647	·4	·717	·9	·964	·4	·412
0·5	·767	3·0	5·687	5·5	·763	8·0	8·017	10·5	·471
·6	·801	·1	·727	·6	·810	·1	·072	·6	·537
·7	·836	·2	·767	·7	·857	·2	·126	·7	·601
·8	·871	·3	·807	·8	·904	·3	·181	·8	·665
·9	·905	·4	·848	·9	·951	·4	·236	·9	·728
1·0	4·940	3·5	·890	6·0	6·998	8·5	·291	11·0	9·792
·1	·975	·6	·930	·1	7·047	·6	·347	·1	·857
·2	5·011	·7	·972	·2	·095	·7	·404	·2	·923
·3	·047	·8	6·014	·3	·144	·8	·461	·3	·989
·4	·082	·9	·056	·4	·193	·9	·517	·4	10·054
1·5	·118	4·0	6·097	6·5	·242	9·0	8·574	11·5	·120
·6	·155	·1	·140	·6	·292	·1	·632	·6	·187
·7	·191	·2	·183	·7	·312	·2	·690	·7	·255
·8	·228	·3	·226	·8	·392	·3	·748	·8	·322
·9	·265	·4	·270	·9	·412	·4	·807	·9	·389
2·0	5·302	4·5	·313	7·0	7·492	9·5	·865	12·0	10·457
·1	·340	·6	·357	·1	·544	·6	·925	·1	·526
·2	·378	·7	·401	·2	·595	·7	·985	·2	·596
·3	·416	·8	·445	·3	·647	·8	9·045	·3	·665
·4	·454	·9	·490	·4	·699	·9	·105	·4	·734

TABLES REQUIRED IN WATER ANALYSIS. TABLE I.—*continued.*

°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.
12·5	10·804	17·1	14·513	21·7	19·305	26·3	25·438	30·9	33·215
·6	·875	·2	605	·8	423	·4	·588	31·0	33·405
·7	·947	·3	·697	·9	541	26·5	·738	·1	·596
8	11·019	4	·790	22·0	19·659	·6	·891	·2	·787
·9	·090	17·5	882	1	·780	·7	26·045	·3	·980
13·0	11·162	·6	·977	·2	·901	·8	·198	·4	34·174
1	·235	·7	15·072	·3	20·022	·9	·351	31·5	·368
·2	·309	8	167	·4	·143	27·0	26·505	·6	·564
·3	·383	·9	262	22·5	·265	·1	·663	·7	·761
·4	·456	18·0	15·357	·6	·389	·2	·820	·8	·959
13·5	·530	·1	451	·7	·511	·3	·978	·9	35·159
·6	·605	·2	552	·8	·634	·4	27·136	32·0	35·359
7	·681	·3	·650	9	762	27·5	294	·1	559
·8	·757	·4	·747	23·0	20·888	6	·455	·2	·760
·9	·832	18·5	·845	·1	21·016	·7	·617	·3	·962
14·0	11·908	·6	·945	·2	·144	·8	·778	·4	36·165
·1	·986	·7	16·045	·3	·272	·9	·939	32·5	·370
·2	12·064	·8	·145	4	·400	28·0	28·101	·6	·576
·3	·142	·9	·246	23·5	528	1	·267	7	·783
·4	·220	19·0	16·346	·6	21·659	·2	·433	8	·9[illegible]
14·5	·298	·1	·449	·7	·790	·3	·599	·9	37·2[illegible]
·6	378	·2	552	·8	·921	·4	·765	33·0	37·410
·7	·458	3	·655	·9	22·053	28·5	·931	·1	·621
·8	·538	·4	·758	24·0	22·184	6	29·101	2	·832
·9	·619	19·5	861	1	·319	7	·271	·3	38·045
15·0	12·699	6	·967	2	·453	·8	·441	4	258
1	·781	·7	17·073	·3	·588	·9	·612	33·5	·473
·2	·864	·8	·179	·4	·723	29·0	29·782	6	·689
·3	·947	·9	·285	24·5	·858	·1	956	·7	·906
·4	13·029	20·0	17·391	·6	·996	·2	30·131	·8	39·124
15·5	·112	·1	·500	·7	23·135	·3	·305	·9	·344
·6	·197	·2	·608	·8	·278	·4	·479	34·0	39·565
·7	·281	·3	·717	·9	·411	29·5	·654	·1	·786
·8	·366	·4	·826	25·0	23·550	·6	·833	·2	40·007
·9	·451	20·5	·935	·1	·692	·7	31·011	·3	·230
16·0	13·536	·6	18·047	·2	·834	·8	·190	·4	·455
·1	·623	·7	·159	·3	·976	·9	·369	34·5	·680
·2	·710	·8	·271	·4	24·119	30·0	31·548	·6	·907
·3	·797	·9	·383	25·5	·261	·1	·729	·7	41·135
·4	·885	21·0	18·495	·6	406	·2	·911	·8	·364
16·5	·972	·1	·610	·7	·552	3	32·094	·9	·595
·6	14·062	·2	·721	·8	·697	·4	·278	35·0	·827
·7	·151	·3	·839	·9	·842	30·5	·463		
·8	·241	·4	·954	26·0	21·988	·6	·650		
·9	·331	21·5	19·069	·1	25·138	·7	·837		
17·0	14·421	·6	·187	·2	·288	·8	33·026		

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

II. *Reduction of Cubic Centimetres of Nitrogen to Grams.*

Log. $\frac{0{\cdot}0012507}{(1+{\cdot}003665\,t)\,760}$ for each tenth of a degree from 0° to 30° C.

t. °C	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
0	6·21634	618	602	586	570	554	539	523	507	491
1	475	459	443	427	411	395	379	363	347	332
2	317	301	285	269	253	237	221	205	189	174
3	159	143	127	112	096	080	065	049	033	018
4	002	986	$\overline{970}$	955	939	923	908	$\overline{892}$	$\overline{876}$	$\overline{861}$
5	6·20845	829	813	798	782	766	751	735	719	704
6	6·20689	673	658	642	627	611	596	580	565	549
7	534	518	503	487	472	456	441	425	410	394
8	379	364	348	333	317	302	286	271	255	240
9	225	210	194	179	163	148	132	117	101	086
10	071	056	040	025	009	994	$\overline{979}$	963	$\overline{948}$	932
11	6·19917	902	887	872	856	841	826	811	796	780
12	6·19765	750	735	720	704	689	674	659	644	628
13	613	598	583	568	552	537	522	507	492	476
14	461	446	431	416	401	386	371	356	341	325
15	310	295	280	265	250	235	220	205	190	174
16	159	144	129	114	099	084	069	054	039	024
17	009	$\overline{994}$	979	$\overline{964}$	$\overline{949}$	$\overline{934}$	919	$\overline{904}$	$\overline{889}$	$\overline{874}$
18	$\overline{6}$·18859	844	829	814	799	784	769	754	739	724
19	710	695	680	665	650	635	620	606	591	576
20	562	547	532	517	502	487	472	458	443	428
21	414	399	384	369	354	339	324	310	295	280
22	266	251	236	221	206	191	176	162	147	132
23	119	104	089	075	060	045	031	016	002	987
24	$\overline{6}$·17973	958	943	929	914	899	885	870	856	841
25	827	812	797	783	768	753	739	724	710	695
26	681	666	651	637	622	607	593	578	564	549
27	536	521	507	492	478	463	449	434	420	405
28	391	376	362	347	333	318	304	289	275	260
29	247	232	218	203	189	175	160	146	131	117

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

III. *Loss of Nitrogen by Evaporation of NH_3 with Sulphurous Acid.*

Parts per 100,000.

NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N
6·0	1·727	4·8	1·451	3·6	·977	2·4	·503	1·2	·250	·09	·014
5·9	1·707	4·7	1·411	3·5	·937	2·3	·463	1·1	·238	·08	·013
5·8	1·688	4·6	1·372	3·4	·898	2·2	·424	1·0	·226	·07	·012
5·7	1·668	4·5	1·332	3·3	·858	2·1	·384	0·9	·196	·06	·010
5·6	1·648	4·4	1·293	3·2	·819	2·0	·345	·8	·166	·05	·009
5·5	1·628	4·3	1·253	3·1	·779	1·9	·333	·7	·136	·04	·007
5·4	1·609	4·2	1·214	3·0	·740	1·8	·321	·6	·106	·03	·006
5·3	1·589	4·1	1·174	2·9	·700	1·7	·309	·5	·077	·02	·004
5·2	1·569	4·0	1·135	2·8	·661	1·6	·297	·4	·062	·01	·003
5·1	1·549	3·9	1·095	2·7	·621	1·5	·285	·3	·047	·009	·001
5·0	1·530	3·8	1·056	2·6	·582	1·4	·274	·2	·032		
4·9	1·490	3·7	1·016	2·5	·542	1·3	·262	·1	0·17		

IV. *Loss of Nitrogen by Evaporation of NH_3 with Hydric Metaphosphate.*

Parts per 100,000.

Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH	Loss of N	Volume evaporated.	NH_3	Loss of N
100 c.c.	10·0	·483	100 c.c.	8·3	·424	100 c.c.	6·6	·365
,,	9·9	·480	,,	8·2	·421	,,	6·5	·361
,,	9·8	·476	,,	8·1	·417	,,	6·4	·358
,,	9·7	·473	,,	8·0	·414	,,	6·3	·354
,,	9·6	·469	,,	7·9	·410	,,	6·2	·351
,,	9·5	·466	,,	7·8	·407	,,	6·1	·348
,,	9·4	·462	,,	7·7	·403	,,	6·0	·345
,,	9·3	·459	,,	7·6	·400	,,	5·9	·341
,,	9·2	·455	,,	7·5	·396	,,	5·8	·337
,,	9·1	·452	,,	7·4	·393	,,	5·7	·333
,,	9·0	·448	,,	7·3	·389	,,	5·6	·330
,,	8·9	·445	,,	7·2	·386	,,	5·5	·326
,,	8·8	·441	,,	7·1	·382	,,	5·4	·322
,,	8·7	·438	,,	7·0	·379	,,	5·3	·318
,,	8·6	·434	,,	6·9	·375	,,	5·2	·314
,,	8·5	·431	,,	6·8	·372	,,	5·1	·310
,,	8·4	·428	,,	6·7	·368	,,	5·0	·306

TABLES REQUIRED IN WATER ANALYSIS. TABLE IV.—*continued.*

Volume evaporated	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N
100 c.c.	4·9	·302	100 c.c.	2·9	·211	250 c.c.	·9	·096
,,	4·8	·298	,,	2·8	·205	,,	·8	·080
,,	4·7	·294	,,	2·7	·200	,,	·7	·070
,,	4·6	·291	,,	2·6	·195	,,	·6	·060
,,	4·5	·287	,,	2·5	·190	500 c.c.	·5	·050
,,	4·4	·283	,,	2·4	·184	,,	·4	·040
,,	4·3	·279	,,	2·3	·179	,,	·3	·030
,,	4·2	·275	,,	2·2	·174	1000 c.c.	·2	·020
,,	4·1	·271	,,	2·1	·169	,,	·1	·010
,,	4·0	·267	,,	2·0	·164	,,	·09	·009
,,	3·9	·262	,,	1·9	·158	,,	·08	·008
,,	3·8	·257	,,	1·8	·153	,,	·07	·007
,,	3·7	·252	,,	1·7	·148	,,	·06	·006
,,	3·6	·247	,,	1·6	·143	,,	·05	·005
,,	3·5	·242	,,	1·5	·137	,,	·04	·004
,,	3·4	·236	,,	1·4	·132	,,	·03	·003
,,	3·3	·231	,,	1·3	·127	,,	·02	·002
,,	3·2	·226	,,	1·2	·122	,,	·01	·001
,,	3·1	·221	,,	1·1	·117			
,,	3·0	·216	,,	1·0	·112			

V. *Loss of Nitrogen by Evaporation of NH_3 with Sulphurous Acid.*

Parts per 100,000.

N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N
5·0	1·741	3·9	1·425	2·9	·946	1·9	·466	·9	·237	·08	·017
4·9	1·717	3·8	1·378	2·8	·898	1·8	·418	·8	·217	·07	·015
4·8	1·693	3·7	1·330	2·7	·850	1·7	·370	·7	·181	·06	·013
4·7	1·669	3·6	1 282	2·6	·802	1·6	·338	·6	·145	·05	·011
4·6	1·645	3·5	1·234	2·5	·754	1·5	·324	·5	·109	·04	·009
4·5	1·621	3·4	1·186	2·4	·706	1·4	·309	·4	·075	·03	·007
4·4	1·598	3·3	1·138	2·3	·658	1·3	·295	·3	·057	·02	·005
4·3	1·574	3·2	1·090	2·2	610	1·2	·280	·2	·038	·01	·003
4·2	1·550	3·1	1·042	2·1	·562	1·1	·266	·1	·020	·008	·002
4·1	1·521	3·0	·994	2·0	·514	1·0	·252	·09	·018	·007	·001
4·0	1·473										

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

VI. *Loss of Nitrogen by Evaporation of NH_3 with Hydric Metaphosphate.*

Parts per 100,000

Volume evaporated.	N as NH_3	Loss of N	Volume evaporated.	N as NH_3	Loss of N	Volume evaporated.	N as NH_3	Loss of N
100 c.c.	8·2	·482	100 c.c.	5·1	·352	100 c.c.	2·1	·192
,,	8·1	·477	,,	5·0	·347	,,	2·0	·186
,,	8·0	·473	,,	4·9	·343	,,	1·9	·180
,,	7·9	·469	,,	4·8	·338	,,	1·8	·173
,,	7·8	·465	,,	4·7	·334	,,	1·7	·167
,,	7·7	·461	,,	4·6	·329	,,	1·6	·161
,,	7·6	·456	,,	4·5	·324	,,	1·5	·154
,,	7·5	·452	,,	4·4	·319	,,	1·4	·148
,,	7·4	·448	,,	4·3	·315	,,	1·3	·142
,,	7·3	·444	,,	4·2	·310	,,	1·2	·136
,,	7·2	·440	,,	4·1	·305	,,	1·1	·129
,,	7·1	·435	,,	4·0	·301	,,	1·0	·123
,,	7·0	·431	,,	3·9	·296	,,	·9	·117
,,	6·9	·427	,,	3·8	·291	,,	·8	·111
,,	6·8	·423	,,	3·7	·286	250 c.c.	·7	·088
,,	6·7	·419	,,	3·6	·281	,,	·6	·073
,,	6·6	·414	,,	3·5	·277	,,	·5	·061
,,	6·5	·410	,,	3·4	·272	500 c.c.	·4	[illegible]
,,	6·4	·406	,,	3·3	·267	,,	·3	·036
,,	6·3	·402	,,	3·2	·261	1000 c.c.	·2	·024
,,	6·2	·398	,,	3·1	·255	,,	·1	·012
,,	6·1	·394	,,	3·0	·249	,,	·09	·011
,,	6·0	·389	,,	2·9	·242	,,	·08	·010
,,	5·9	·385	,,	2·8	·236	,,	·07	·008
,,	5·8	·381	,,	2·7	·230	,,	·06	·007
,,	5·7	·377	,,	2·6	·223	,,	·05	·006
,,	5·6	·373	,,	2·5	·217	,,	·04	·005
,,	5·5	·368	,,	2·4	·211	,,	·03	·004
,,	5·4	·364	,,	2·3	·205	,,	·02	·002
,,	5·3	·360	,,	2·2	·198	,,	·01	·001
,,	5·2	·356						

VII. *Table of Hardness.*

(50 c.c. of water used.)

Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.*	Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.	Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.
c.c.			c.c.			c.c.		
0·7	0·00	0·00	1·3	0·95	0·67	1·9	1·82	1·27
0·8	0·16	0·11	·4	1·11	0·78	2·0	1·95	1·37
0·9	0·32	0·22	·5	1·27	0·89	·1	2·08	1·46
1·0	0·48	0·34	·6	1·43	1·00	·2	2·21	1·55
·1	0·63	0·44	·7	1·56	1·09	·3	2·34	1·64
·2	0·79	0·55	·8	1·69	1·18	·4	2·47	1·73

* Each degree of hardness indicates one grain of $CaCO_3$ per gallon.

TABLES REQUIRED IN WATER ANALYSIS. TABLE VII.—*continued.*

Volume of Soap solution.	CaCO₃ per 100,000	Degrees of Hardness.*	Volume of Soap solution.	CaCO₃ per 100,000	Degrees of Hardness.	Volume of Soap solution.	CaCO₃ per 100,000	Degrees of Hardness.
c.			c.c.			c.c.		
2·5	2·60	1·82	7·1	9·00	6·30	11·7	15·95	11·17
·6	2·73	1·91	·2	9·14	6·40	·8	16·11	11·28
·7	2·86	2·00	·3	9·29	6·50	·9	16·27	11·39
·8	2·99	2·09	·4	9·43	6·60	12·0	16·43	11·50
·9	3·12	2·18	·5	9·57	6·70	·1	16·59	11·61
3·0	3·25	2·28	·6	9·71	6·80	·2	16·75	11·73
·1	3·38	2·37	·7	9·86	6·90	·3	16·90	11·83
·2	3·51	2·46	·8	10·00	7·00	·4	17·06	11·94
·3	3·64	2·55	·9	10·15	7·11	·5	17·22	12·05
·4	3·77	2·64	8·0	10·30	7·21	·6	17·38	12·17
·5	3·90	2·73	·1	10·45	7·32	·7	17·54	12·28
·6	4·03	2·82	·2	10·60	7·42	·8	17·70	12·39
·7	4·16	2·91	·3	10·75	7·53	·9	17·86	12·50
·8	4·29	3·00	·4	10·90	7·63	13·0	18·02	12·61
·9	4·43	3·10	·5	11·05	7·74	·1	18·17	12·72
4·0	4·57	3·20	·6	11·20	7·84	·2	18·33	12·83
·1	4·71	3·30	·7	11·35	7·95	·3	18·49	12·94
·2	4·86	3·40	·8	11·50	8·05	·4	18·65	13·06
·3	5·00	3·50	·9	11·65	8·16	·5	18·81	13·17
·4	5·14	3·60	9·0	11·80	8·26	·6	18·97	13·28
·5	5·29	3·70	·1	11·95	8·37	·7	19·13	13·39
·6	5·43	3·80	·2	12·11	8·48	·8	19·29	13·50
·7	5·57	3·90	·3	12·26	8·58	·9	19·44	13·61
·8	5·71	4·00	·4	12·41	8·69	14·0	19·60	13·72
·9	5·86	4·10	·5	12·56	8·79	·1	19·76	13·83
5·0	6·00	4·20	·6	12·71	8·90	·2	19·92	13·94
·1	6·14	4·30	·7	12·86	9·00	·3	20·08	14·06
·2	6·29	4·40	·8	13·01	9·11	·4	20·24	14·17
·3	6·43	4·50	·9	13·16	9·21	·5	20·40	14·28
·4	6·57	4·60	10·0	13·31	9·32	·6	20·56	14·39
·5	6·71	4·70	·1	13·46	9·42	·7	20·71	14·50
·6	6·86	4·80	·2	13·62	9·53	·8	20·87	14·61
·7	7·00	4·90	·3	13·76	9·63	·9	21·03	14·72
·8	7·14	5·00	·4	13·91	9·74	15·0	21·19	14·83
·9	7·29	5·10	·5	14·06	9·84	·1	21·35	14·95
6·0	7·43	5·20	·6	14·21	9·95	·2	21·51	15·06
·1	7·57	5·30	·7	14·37	10·06	·3	21·68	15·18
·2	7·71	5·40	·8	14·52	10·16	·4	21·85	15·30
·3	7·86	5·50	·9	14·68	10·28	·5	22·02	15·41
·4	8·00	5·60	11·0	14·84	10·39	·6	22·18	15·53
·5	8·14	5·70	·1	15·00	10·50	·7	22·35	15·65
·6	8·29	5·80	·2	15·16	10·61	·8	22·52	15·76
·7	8·43	5·90	·3	15·32	10·72	·9	22·69	15·88
·8	8·57	6·00	·4	15·48	10·84	16·0	22·86	16·00
·9	8·71	6·10	·5	15·63	10·94			
7·0	8·86	6·20	·6	15·79	11·05			

* Each degree of hardness indicates one grain of CaCO₃ per gallon.

TABLES REQUIRED IN WATER ANALYSIS—*continued*

VIII. *Clark's Table of Hardness of Water.*

Degrees of Hardness.	Measures of Soap solution.	Differences for the next 1° of Hardness	Degrees of Hardness.	Measures of Soap solution.	Differences for the next 1° of Hardness.
0 (distilled water)	1·4	1·8	8	17·5	1·9
			9	19·4	1·9
1	3·2	2·2	10	21·3	1·8
2	5·4	2·2	11	23·1	1·8
3	7·6	2·0	12	24·9	1·8
4	9·6	2·0	13	26·7	1·8
5	11·6	2·0	14	28·5	1·8
6	13·6	2·0	15	30·3	1·7
7	15·6	1·9	16	32·0	..

Each measure equals 10 grains the quantity of water operated upon equal 1000 grains, and each "degree of hardness" indicates 1 grain of calcic carbonate per gallon.

THE DETERMINATION OF NITRATES IN WATER BY PHENOL DISULPHONIC ACID

(Sprengel's method modified.)

Solutions required.

(1) *Phenol disulphonic Acid.* Mix together 2 parts by measure of phenol,* liquefied by heat, and 5 parts of pure concentrated sulphuric acid, and heat in a porcelain basin on the water bath for about 8 hours, with occasional stirring. When cool, add $1\frac{1}{2}$ volumes of water and $\frac{1}{2}$ volume strong hydrochloric acid to each volume of the phenol-disulphonic acid.

Convenient quantities are 80 c.c. phenol, 200 c.c. H_2SO_4; 420 c.c. water and 140 c.c. HCl, producing 840 c.c. of a light brown solution, which is ready for immediate use.

(2) *Standard Potassium Nitrate.* 0·0722 gram KNO_3 crystals are dissolved in a litre of water.†

10 c.c. = 0·0001 gram N, or 1 part of N in 100,000 of water when 10 c.c. are evaporated.

(3) 10% ammonia (1 vol. ·880 + 2 vols. water); or potash solution, made by dissolving 330 grams stick potash in one litre of water.

About 15 c.c. of either of the above to be used for each residue.

The determination is made as follows: 10 c.c. of the water under examination and 10 c.c. standard KNO_3 are pipetted into 15 c.c. beakers and evaporated nearly to dryness on a hot iron plate, the operation being completed on the top of the water-oven. To each residue 1 c.c. of the phenol-disulphonic acid solution is added, and the latter brought into contact with the whole of the residue in each beaker. This is done simply by rotating the beaker, held in an inclined position, until the entire residue has been moistened: no stirring rod is required. The beakers are then left on the top of the water-oven for 15 minutes and at the end of that time are at once filled up with cold water and removed to the working-bench, if a number of residues are being treated simultaneously. The standard solution is then rinsed into a 100 c.c. graduated cylinder, a slight excess (about 15 c.c.) of 10% ammonia or of caustic potash solution added, the 100 c.c. made up by the addition of water, and the yellow liquid transferred to a Nessler glass (6 × 1½ ins.). Each of the other beakers is then successively treated in the same way and comparison made with the standard as in Nesslerizing. The colours are best compared when the Nessler glasses are held side by side at a short distance above a thick white filter paper.

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* Calvert's No. 1 medical carbolic acid answers well.

† Or dissolve 0·7217 gram KNO_3 in a litre of distilled water. 1 c.c. of this may be used for a standard, but it is better to dilute 50 c.c. to 500 c.c. and measure out 10 c.c. of the latter for each set of determinations.

The results obtained with the aid of Table IX. are only approximate when more than about 1·5 parts of nitric nitrogen per 100,000 of water are present. In all cases where the nitric nitrogen exceeds 1·5 parts per 100,000, it is necessary to make a second determination, using such a volume of water as to give a colour very nearly equal to that of the standard.* Thus, if a water showed 2 parts of nitric nitrogen per 100,000, 5 c.c. should be evaporated to dryness and treated as before: one giving 4 parts would really contain decidedly more, and 20 c.c. of the sample should be transferred to a 100 c.c. measuring flask, diluted to the mark with water, and 10 c.c. of the thoroughly mixed solution (=2 c.c. original water) evaporated down for a fresh determination. In the case of very good waters, the solution and washings should be kept as small as possible, since a portion of the standard 100 c.c. will have to be poured into the cylinder in order to match the colours. Suppose that 0·25 part of nitric nitrogen is thus shown, then 40 c.c. of the water are measured into a larger beaker, evaporated to a small bulk, rinsed into a small beaker and evaporated to dryness, etc., as above; or 20 c.c. of the water may be taken and compared with a standard made by using only 5 c.c. of the KNO_3 solution. (This method is inapplicable in the presence of thiocyanates†).

Chamot, Pratt and Redfield‡ have recently made a study of this method, and their results may briefly be summarized as follows:—

A modified phenol-sulphonic acid method. Preparation of reagents required.

Phenol-disulphonic acid.—Dissolve 25 gm. of pure white phenol in 150 c.c. of pure concentrated sulphuric acid, add 75 c.c. of fuming sulphuric acid (13% SO_3), stir well, and heat for 2 hours at about 100° C.

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* If the second experiment is to be made the same day, the same standard, if covered with a beaker, can be used again.

† See H. Silvester, *Journ. Soc. Chem. Ind.*, 1912, **31**, 95.

‡ *The Chemical News*, 1911, **104**, p. 146, *et seq.*

Standard silver sulphate.- 4·3969 gm. of silver sulphate (free from nitrate) to the litre.

1 c.c. = 1 c.c. of standard $AgNO_3$ (1·6186 gm. per litre) equivalent to 0·001 gram chlorine.

Method of procedure. First determine the alkalinity, the chlorine and nitrite content, and the colour of the sample. Should the colour be high, decolorize with "aluminium cream."

Measure out such a volume of the water (100 c.c. or less) as will contain about 1 part of nitric nitrogen per 100,000, fairly low colorimeter readings having been found most reliable. Add sufficient N/25 or N/50 sulphuric acid barely to neutralize the alkalinity, then enough standard silver sulphate solution to precipitate all but 0·5 mgm. of the chlorine. Heat to boiling, add a little aluminium cream, filter, and wash with small amounts of hot water. Evaporate the filtrates to dryness, add 2 c.c. of the disulphonic acid reagent, rubbing with a glass rod to ensure intimate contact. Should the residue be compact or vitreous in appearance from the presence of much magnesium or iron, place the evaporator on the water bath for a few minutes. Dilute with water and add slowly KOH solution (10–12 normal) until the maximum colour is developed. Transfer to a colorimeter cylinder, filtering if necessary, and compare with a potassium nitrate or tripotassium nitrophenol disulphonate standard.

Should nitrites be present in excess of 0·1 part of nitrous nitrogen per 100,000, a slight error will be introduced. They should, therefore, be removed by heating the sample a few moments with a few drops of hydrogen peroxide (free from nitrates) repeatedly added, or dilute potassium permanganate may be added in the cold until a trace of pink appears and a correction applied to the final nitrate nitrogen reading due to the conversion of the nitrites to nitrates.

Directions for making permanent standards are given.

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

IX. *Estimation of Nitrogen as Nitrates by Sprengel's Method (for waters containing more than one part of N in* 100,000).

No. of c.c. of yellow solution equal to the standard 100 c.c.	Nitrogen as Nitrates.		No. of c.c. of yellow solution equal to the standard 100 c.c.	Nitrogen as Nitrates.	
	Parts per 100,000.	Grains per gallon.		Parts per 100,000.	Grains per gallon.
100	1·00	0·70	50	2·00	1·40
95	1·05	0·74	48	2·08	1·46
90	1·11	0·78	46	2·17	1·52
85	1·18	0·83	45	2·22	1·55
80	1·25	0·88	44	2·27	1·59
78	1·28	0·90	42	2·38	1·67
76	1·32	0·92	40	2·50	1·75
75	1·33	0·93	38	2·63	1·84
74	1·35	0·95	36	2·78	1·95
72	1·39	0·97	35	2·86	2·00
70	1·43	1·00	34	2·94	2·06
68	1·47	1·03	32	3·16	2·19
66	1·51	1·06	30	3·33	2·33
65	1·54	1·08	28	3·57	2·50
64	1·55	1·09	26	3·85	2·70
62	1·61	1·13	25	4·00	2·80
60	1·67	1·17	24	4·17	2·92
58	1·72	1·20	22	4·55	3·19
56	1·78	1·25	20	5·00	3·50
55	1·82	1·27	18	5·55	3·89
54	1·85	1·30	16	6·25	4·38
52	1·92	1·34	15	6·67	4·67

X. *Table for the Conversion of Parts per* 100,000 *into Grains per Gallon.*

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
1	0·7	9	6·3	17	11·9	25	17·5
2	1·4	10	7·0	18	12·6	26	18·2
3	2·1	11	7·7	19	13·3	27	18·9
4	2·8	12	8·4	20	14·0	28	19·6
5	3·5	13	9·1	21	14·7	29	20·3
6	4·2	14	9·8	22	15·4	30	21·0
7	4·9	15	10·5	23	16·1	31	21·7
8	5·6	16	11·2	24	16·8	32	22·4

TABLES REQUIRED IN WATER ANALYSIS. TABLE X. *continued.*

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
33	23·1	78	54·6	123	86·1	168	117·6
34	23·8	79	55·3	124	86·8	169	118·3
35	24·5	80	56·0	125	87·5	170	119·0
36	25·2	81	56·7	126	88·2	171	119·7
37	25·9	82	57·4	127	88·9	172	120·4
38	26·6	83	58·1	128	89·6	173	121·1
39	27·3	84	58·8	129	90·3	174	121·8
40	28·0	85	59·5	130	91·0	175	122·5
41	28·7	86	60·2	131	91·7	176	123·2
42	29·4	87	60·9	132	92·4	177	123·9
43	30·1	88	61·6	133	93·1	178	124·6
44	30·8	89	62·3	134	93·8	179	125·3
45	31·5	90	63·0	135	94·5	180	126·0
46	32·2	91	63·7	136	95·2	181	126·7
47	32·9	92	64·4	137	95·9	182	127·4
48	33·6	93	65·1	138	96·6	183	128·1
49	34·3	94	65·8	139	97·3	184	128·8
50	35·0	95	66·5	140	98·0	185	129·5
51	35·7	96	67·2	141	98·7	186	130·2
52	36·4	97	67·9	142	99·4	187	130·9
53	37·1	98	68·6	143	100·1	188	131·6
54	37·8	99	69·3	144	100·8	189	132·3
55	38·5	100	70·0	145	101·5	190	133·0
56	39·2	101	70·7	146	102·2	191	133·7
57	39·9	102	71·4	147	102·9	192	134·4
58	40·6	103	72·1	148	103·6	193	135·1
59	41·3	104	72·8	149	104·3	194	135·8
60	42·0	105	73·5	150	105·0	195	136·5
61	42·7	106	74·2	151	105·7	196	137·2
62	43·4	107	74·9	152	106·4	197	137·9
63	44·1	108	75·6	153	107·1	198	138·6
64	44·8	109	76·3	154	107·8	199	139·3
65	45·5	110	77·0	155	108·5	200	140·0
66	46·2	111	77·7	156	109·2	201	140·7
67	46·9	112	78·4	157	109·9	202	141·4
68	47·6	113	79·1	158	110·6	203	142·1
69	48·3	114	79·8	159	111·3	204	142·8
70	49·0	115	80·5	160	112·0	205	143·5
71	49·7	116	81·2	161	112·7	206	144·2
72	50·4	117	81·9	162	113·4	207	144·9
73	51·1	118	82·6	163	114·1	208	145·6
74	51·8	119	83·3	164	114·8	209	146·3
75	52·5	120	84·0	165	115·5	210	147·0
76	53·2	121	84·7	166	116·2	211	147·7
77	53·9	122	85·4	167	116·9	212	148·4

TABLES REQUIRED IN WATER ANALYSIS. TABLE X.—*continued.*

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
213	149·1	223	156·1	233	163·1	243	170·1
214	149·8	224	156·8	234	163·8	244	170·8
215	150·5	225	157·5	235	164·5	245	171·5
216	151·2	226	158·2	236	165·2	246	172·2
217	151·9	227	158·9	237	165·9	247	172·9
218	152·6	228	159·6	238	166·6	248	173·6
219	153·3	229	160·3	239	167·3	249	174·3
220	154·0	230	161·0	240	168·0	250	175·0
221	154·7	231	161·7	241	168·7		
222	155·4	232	162·4	242	169·4		

CALCULATION OF THE RESULTS OF WATER ANALYSIS.

Substance estimated.	Quantity of Water taken.	To get Grains per gallon	Logarithms.
N as NO_3 (Crum)	250 c.c.	*c.c. of NO at N.T.P. × ·17535 = N	$\bar{1}$·243 861
NH_3 (copper zinc)	100 c.c.	grams of NH_3 × 575·73 = N	2·760 2900
„ (aluminium)	50 c.c.	„ × 1151·46 = N	3·061 2500
O absorbed	250 c.c. + 10 c.c. $K_2Mn_2O_8$	$0.28\left(\frac{S-W}{S}\right)$†	
„	250 c.c. + 15 c.c. $K_2Mn_2O_8$	$0.28\left(\frac{1.5S-W}{S}\right)$†	
Total solids	250 c.c.	grains × 280	2·447 1580

* **Or thus.** Let v = vol. of NO obtained from 250 c.c. of the water
b = height of Bar.
w = tension of aqueous vapour at the observed temperature (see Table I.).

Then N in grains per gallon $= v \times \frac{\cdot0012507}{760(1+\cdot00367\,t)} \times (b - w) \times 140$

For logs. of $\frac{\cdot0012507}{760(1+\cdot00367\,t)}$ for different values of t see Table II

Log. 140 = 2·1461280.

† S = c.c. of $Na_2S_2O_3$ corresponding to 10 c.c. $K_2Mn_2O_8$.
W = „ „ required by the water under examination.

THRESH'S SOLUTION OF STARCH AND DETECTION OF NITRITES.

Thresh states that, having tried numerous formulæ for starch solutions, he finds that the only one that can be relied on is the following: –

Starch	4 grams.
Zinc chloride	20 ,,
Water	1 litre.

Dissolve the zinc chloride in about 100 c.c. of water, and filter. Mix the starch with a few c.c. of cold water into a thin paste, and pour into the boiling solution of zinc chloride with constant stirring. Dilute to a litre. Allow the flocculent matter to settle, and filter the supernatant fluid through a small jelly-bag.

Detection of Nitrites – To 50 c.c. of the water (previously aerated by well shaking) add 1 c.c. each of dilute HCl (1 in 6), potassium iodide solution (10 per cent.), and the above starch solution and stir. If no blue colour develops in two minutes, nitrites may be considered to be absent. With 0·1 part of nitrous nitrogen in 100,000 a dark blue colour is produced instantly, with 0·03 part per 100,000 the colour appears in a few seconds, and with 0·01 per 100,000 in about thirty seconds.*

EXAMPLE OF THE DETERMINATION OF NITRATES BY CRUM'S METHOD.

0·5 gram of a substance containing nitrate of soda treated by Crum's method gave 13·6 c.c. of NO measured at 8° C. and 737 mm. Bar. To find the percentages of nitrogen and of sodium nitrate present.

Bar. 737 mm.

Tension of aqueous vapour at 8° C. 8 mm. by Table I.

Pressure on the dry gas 729 mm.

NO contains half its volume of nitrogen.

$$\text{Weight of nitrogen} = \frac{v}{2}(b - w) \times \frac{\cdot 0012507}{760(1 + \cdot 00367t)}$$

$$= 6\cdot 8 \times 729 \times \frac{\cdot 0012507}{760(1 + \cdot 00367 \times 8)}$$

$$\begin{array}{lr} \text{log. } 6\cdot 8 & = 0\cdot 83251 \\ \text{,, } 729 & 2\cdot 86273 \\ \text{log. fraction by Table II.} & \bar{6}\cdot 20379 \\ \hline & \bar{3}\cdot 89903 \end{array} = 0\cdot 007926 \text{ gram}$$

Nitrogen in 0·5 gram

$\cdot 007926 \times 200 = \cdot 59\%$ nitrogen

and by logs. 1·59 nitrogen = 9·65% sodium nitrate.

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* From Dr Thresh's *The Examination of Water and Water Supplies*, Second edition, 1913, p. 292.

Water and Sewage Examination Results.

(British Association Report, 1899.)

The Committee appointed by the British Association to devise a uniform system of recording the results of the chemical and bacteriological examination of water and sewage reported as follows:—

It is desirable that results of analysis should be expressed in *parts per* 100,000, except in the case of dissolved gases, when these should be stated as c.c. of gas at 0° C and 760 mm. in 1 litre of water. This method of recording results is in accordance with that suggested by the Committee appointed in 1887 to confer with the Committee of the American Association for the advancement of science, with a view to forming a uniform system of recording the results of water analysis.

It is suggested that in the case of all nitrogen compounds the results be expressed as parts of nitrogen per 100,000, including the ammonia expelled on boiling with alkaline permanganate, which should be termed *albuminoid nitrogen*. The nitrogen will therefore be returned as:

(1) Ammoniacal nitrogen from free and saline ammonia.
(2) Nitrous nitrogen from nitrites.
(3) Nitric nitrogen from nitrates.
(4) Organic nitrogen (either by Kjeldahl or by combustion, but the process used should be stated).
(5) Albuminoid nitrogen.

The total nitrogen of all kinds will be the sum of the first four determinations

The Committee are of opinion that the percentage of nitrogen oxidized—that is, the ratio of (2) and (3) to (1) and (4) gives sometimes a useful measure of the stage of purification of a particular sample. The purification effected by a process will be measured by the amount of oxidized nitrogen as compared with the total amount of nitrogen existing in the crude sewage.

In raw sewage and in effluents containing suspended matter, it is also desirable to determine how much of the organic nitrogen is present in the suspended matter.

In sampling, the Committee suggest that the bottles should be filled nearly completely with the liquid, only a small air-bubble being allowed to remain in the neck of the bottle. The time at which a sample is drawn, as well as the time at which its analysis is begun, should be noted. An effluent should be drawn to correspond as nearly as possible with the original sewage, and both it and the sewage should be taken in quantities proportional to the rate of flow when that varies (*e.g.* in the emptying of a filter-bed).

In order to avoid the multiplication of analyses, the attendant at a sewage works (or any other person who draws the samples) might be provided with sets of twelve or twenty-four stoppered quarter-Winchester bottles, one of which should be filled every hour or every two hours, and on the label of each bottle the rate of flow at the time should be written. When the bottles reach the laboratory, quantities would be taken from each proportional to these rates of flow and mixed together, by which means a fair average sample for the twenty-four hours would be obtained.

The Committee were unable to suggest a method of reporting bacterial results, including incubator tests, that would be likely to be acceptable to all workers.

The Committee consisted of Professor W. Ramsay (chairman), Sir W. Crookes, Professors F. Clowes, P. F. Frankland, and R. Boyce, and Dr Rideal (secretary).

STANDARDS FOR SEWAGE EFFLUENTS.

In 1898 a Royal Commission was appointed to inquire and report what methods of treating and disposing of sewage (including any liquid from any factory or manufacturing process) may properly be adopted. Between 1902 and 1913 eight Reports were issued and the Final Report* in 1915. The principal conclusions finally arrived at were briefly as follows: -

The nuisance producing power of a normal sewage or effluent is proportional to its power of deoxygenating the water of the stream into which it is discharged.

The dissolved oxygen absorption test provides the most trustworthy chemical index of the actual state of a stream and should be adopted for purposes of a standard.

A river of average purity shows an absorption of 0·2 part per 100,000 of dissolved oxygen in 5 days at the temperature of 65° F.

For administrative reasons a fixed general standard should be applied to the effluent alone, and should be relaxed or made more stringent as local circumstances permitted or required. This general or normal standard for effluents is thus defined.

An effluent in order to comply with the general standard must not contain as discharged more than 3 parts per 100,000 of suspended matter, and with its suspended matters included must not take up at 65° F. (18·3° C.) more than 2 parts per 100,000 of dissolved oxygen in 5 days.

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* Royal Commission on Sewage Disposal. Final Report, Feb. 11, 1915 [Cd. 7821].

TABLE GIVING THE AMOUNTS OF DISSOLVED OXYGEN IN DISTILLED WATER AT VARIOUS TEMPERATURES (BAR. 760 mm.).*

Temperature °C.	Oxygen (parts per 100,000).	Temperature °C.	Oxygen (parts per 100,000).	Temperature °C.	Oxygen (parts per 100,000).
0	1·42	11	1·09	21	0·88
1	1·39	12	1·07	22	0·87
2	1·36	13	1·04	23	0·85
3	1·32	14	1·02	24	0·84
4	1·28	15	1·00	25	0·82
5	1·24	16	0·98	26	0·81
6	1·22	17	0·96	27	0·80
7	1·19	18	0·94	28	0·80
8	1·17	19	0·92	29	0·79
9	1·14	20	0·90	30	0·78
10	1·11				

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* Calculated from Roscoe and Lunt's table (*Trans. Chem. Soc.*, 1889, 569) for temperatures from 5°-30° C. The values given for 0°-4° are based on determinations by Winkler's process.

STATUTORY TABLE FOR DETERMINING THE ORIGINAL GRAVITY OF WORTS OF BEER BY THE DISTILLATION PROCESS.*

Spirit Indication	Degrees of Original Specific Gravity	Spirit Indication.	Degrees of Original Specific Gravity.	Spirit Indication	Degrees of Original Specific Gravity	Spirit Indication	Degrees of Original Specific Gravity
·0	·00 (a)	4·1	17·75 (d)	8·2	36·58 (f)	12·3	56·38 (k)
·1	·42 (a)	4·2	18·21 (e)	8·3	37·04 (e)	12·4	56·89 (k)
·2	·85 (b)	4·3	18·66 (d)	8·4	37·51 (f)	12·5	57·40 (k)
·3	1·27 (a)	4·4	19·12 (e)	8·5	37·97 (e)	12·6	57·91 (k)
·4	1·70 (b)	4·5	19·57 (d)	8·6	38·44 (f)	12·7	58·42 (k)
·5	2·12 (a)	4·6	20·03 (e)	8·7	38·90 (e)	12·8	58·93 (k)
·6	2·55 (b)	4·7	20·48 (d)	8·8	39·37 (f)	12·9	59·44 (k)
·7	2·97 (a)	4·8	20·94 (e)	8·9	39·83 (e)	13·0	59·95 (k)
·8	3·40 (b)	4·9	21·39 (d)	9·0	40·30 (f)	13·1	60·46 (k)
·9	3·82 (a)	5·0	21·85 (e)	9·1	40·77 (f)	13·2	60·97 (k)
1·0	4·25 (b)	5·1	22·30 (d)	9·2	41·24 (f)	13·3	61·48 (k)
1·1	4·67 (a)	5·2	22·76 (e)	9·3	41·71 (f)	13·4	61·99 (k)
1·2	5·10 (b)	5·3	23·21 (d)	9·4	42·18 (f)	13·5	62·51 (l)
1·3	5·52 (a)	5·4	23·67 (e)	9·5	42·65 (f)	13·6	63·03 (l)
1·4	5·95 (b)	5·5	24·12 (d)	9·6	43·12 (f)	13·7	63·52 (l)
1·5	6·37 (a)	5·6	24·58 (e)	9·7	43·59 (f)	13·8	64·03 (l)
1·6	6·80 (b)	5·7	25·03 (d)	9·8	44·06 (f)	13·9	64·54 (l)
1·7	7·22 (a)	5·8	25·49 (e)	9·9	44·53 (f)	14·0	65·10 (l)
1·8	7·65 (b)	5·9	25·94 (d)	10·0	45·00 (f)	14·1	65·62 (l)
1·9	8·07 (a)	6·0	26·40 (e)	10·1	45·48 (g)	14·2	66·14 (l)
2·0	8·50 (b)	6·1	26·86 (e)	10·2	45·97 (h)	14·3	66·66 (l)
2·1	8·94 (c)	6·2	27·32 (e)	10·3	46·45 (g)	14·4	67·18 (l)
2·2	9·38 (c)	6·3	27·78 (e)	10·4	46·94 (h)	14·5	67·70 (l)
2·3	9·82 (c)	6·4	28·24 (e)	10·5	47·42 (g)	14·6	68·22 (l)
2·4	10·26 (c)	6·5	28·70 (e)	10·6	47·91 (h)	14·7	68·74 (l)
2·5	10·70 (c)	6·6	29·16 (e)	10·7	48·39 (g)	14·8	69·26 (l)
2·6	11·14 (c)	6·7	29·62 (e)	10·8	48·88 (h)	14·9	69·78 (l)
2·7	11·58 (c)	6·8	30·08 (e)	10·9	49·36 (g)	15·0	70·30 (l)
2·8	12·02 (c)	6·9	30·54 (e)	11·0	49·85 (h)	15·1	70·83 (m)
2·9	12·46 (c)	7·0	31·00 (e)	11·1	50·35 (i)	15·2	71·36 (m)
3·0	12·90 (c)	7·1	31·46 (e)	11·2	50·85 (i)	15·3	71·89 (m)
3·1	13·34 (c)	7·2	31·93 (f)	11·3	51·35 (i)	15·4	72·42 (m)
3·2	13·78 (c)	7·3	32·39 (e)	11·4	51·85 (i)	15·5	72·95 (m)
3·3	14·22 (c)	7·4	32·86 (f)	11·5	52·35 (i)	15·6	73·48 (m)
3·4	14·66 (c)	7·5	33·32 (e)	11·6	52·85 (i)	15·7	74·01 (m)
3·5	15·10 (c)	7·6	33·79 (f)	11·7	53·35 (i)	15·8	74·54 (m)
3·6	15·54 (c)	7·7	34·25 (e)	11·8	53·85 (i)	15·9	75·07 (m)
3·7	15·98 (c)	7·8	34·72 (f)	11·9	54·35 (i)	16·0	75·60 (m)
3·8	16·42 (c)	7·9	35·18 (e)	12·0	54·85 (i)		
3·9	16·86 (c)	8·0	35·65 (f)	12·1	55·36 (k)		
4·0	17·30 (c)	8·1	36·11 (e)	12·2	55·87 (k)		

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* This table, dated November 25, 1914, is the new official table incorporated in the Finance Act, 1914, and replaces the old official tables by Graham, Hofmann, and Redwood that have been in use since 1880.

	·01.	·02.	·03.	·04.	·05.	·06.	·07.	·08.	·09.
(*a*)	·04	·08	·13	·17	·21	·25	·29	·34	·38
(*b*)	·04	·09	·13	·17	·22	·26	·30	·34	·39
(*c*)	·04	·09	·13	·18	·22	·26	·31	·35	·40
(*d*)	·05	·09	·14	·18	·23	·27	·32	·36	·41
(*e*)	·05	·09	·14	·18	·23	·28	·32	·37	·41
(*f*)	·05	·09	·14	·19	·24	·28	·33	·38	·42
(*g*)	·05	·10	·14	·19	·24	·29	·34	·38	·43
(*h*)	·05	·10	·15	·20	·25	·29	·34	·39	·44
(*i*)	·05	·10	·15	·20	·25	·30	·35	·40	·45
(*k*)	·05	·10	·15	·20	·26	·31	·36	·41	·46
(*l*)	·05	·10	·16	·21	·26	·31	·36	·42	·47
(*m*)	·05	·11	·16	·21	·27	·32	·37	·42	·48
(*n*)	·06	·11	·17	·22	·28	·34	·39	·45	·50

The degrees of original gravity corresponding to spirit indications of 0·01–·09 are shown in the sub-table* above.

Ex. Spirit indication, 6·47. From the table 6·4 = 28·24 degrees of original gravity, and since this is lettered (*e*) reference to that line in the sub-table shows that 0·07 = 0·32 degree. Hence 6·47 spirit indication = 28·24 + 0·32 = 28·56 "degrees of gravity lost."

The table given on page 100, which has the force of law, supersedes the tables formerly used, and is due to Sir Edward Thorpe and Dr H. T. Brown working in co-operation. True indications of original gravity may be expected from its use, individual brewery data in the Report† suggesting that it will more often underestimate than overestimate original gravity, but the extreme error should be ±0·5°. For the purpose of the charge of duty the Finance Act of 1914 directs that a deduction of 0·75° shall be allowed in every case from original gravity determinations.

The authorities above mentioned state that fresh worts contain practically no acetic or other volatile acid, and that the amount produced during fermentation and storage is negligibly small so long as the beer remains sound. Hence the determination of acidity may be omitted with all sound beers. In those cases (*e.g.* strong ales which have become markedly acid) where the correction for acidity is necessary, the following table will be required:—

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* The lettering and sub table are additions by the author.

† See *Journ. Inst. Brewing*, 1914, 20, 569–713.

TABLE FOR ASCERTAINING THE VALUE OF THE ACETIC ACID.

Corresponding Degrees of "Spirit Indication."

Excess per cent of Acetic Acid in the beer.	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	..	·02	·04	·06	·07	·08	·09	·11	·12	·13
·1	·14	·15	·17	·18	·19	·21	·22	·23	·24	·26
·2	·27	·28	·29	·31	·32	·33	·34	·35	·37	·38
·3	·39	·40	·42	·43	·44	·46	·47	·48	·49	·51
·4	·52	·53	·55	·56	·57	·59	·60	·61	·62	·64
·5	·65	·66	·67	·69	·70	·71	·72	·73	·75	·76
·6	·77	·78	·80	·81	·82	·84	·85	·86	·87	·89
·7	·90	·91	·93	·94	·95	·97	·98	·99	1·10	1·02
·8	1·03	1·04	1·05	1·07	1·08	1·09	1·10	1·11	1·13	1·14
·9	1·15	1·16	1·18	1·19	1·21	1·22	1·23	1·25	1·26	1·28
1·0	1·29	1·31	1·33	1·35	1·36	1·37	1·38	1·40	1·41	1·42

The determination of acidity is best made by distillation in a current of steam and titration of the distillate. More conveniently, but somewhat less accurately, the volatile acid, calculated as acetic acid, is determined by the loss of acidity of a sample of the beer (50 c.c.) after evaporation to dryness over an open steam-bath.

The "spirit indication" corresponding to the acetic acid thus determined is added to that found by either the distillation or the evaporation process and the original gravity calculated as already described. When the proportion of volatile acid is very high, it affects the density of the distillate and so prevents the accurate determination of the spirit indication. In this case the distillate should be neutralised with sodium hydroxide solution and re-distilled.

Note.—The old official method (1880) of determining acidity by direct titration and subtraction of 0·1 per cent. from the acidity so found is not considered satisfactory. (Graham, Hofmann, and Redwood stated that fresh worts may contain 0·1 per cent. of acetic acid and that all acidity in excess of this amount may be regarded as acetic acid derived from the alcohol of the beer.)

Extract.—By dividing "extract gravity" less 1000 by 4·0 we obtain the weight in grams of dry extract in 100 c.c. of the beer.

Determination of Original Gravity by the (official) Distillation Process.—Worts or unfinished beers containing a sediment of yeast, etc., are required to be filtered before analysis.

A sample of beer is first freed from most of its dissolved carbon dioxide either by pouring it backward and forward from one vessel to another or by means of a mechanical whisk or stirrer. Its temperature is then adjusted to 60° F. and 100 c.c. (75 c.c. will suffice) measured out and transferred to a distilling flask, the measuring flask being rinsed out with about 20 c.c. of water and the rinsings added to the main quantity, which is then distilled. The distillate is received in the measuring flask originally used, about four-fifths of the volume taken being collected. Its temperature is then carefully adjusted to 60° F. and made up to the mark with water also at 60°. The sp. gr. is then taken with a 50 c.c. bottle and the result subtracted from 1000. This gives the "spirit indication," and the corresponding number of "degrees of gravity lost" is found from the table on p. 100. The residue in the distilling flask is rinsed into another 100 c.c. (or 75 c.c.) flask, cooled, the temperature adjusted to 60° F., made up to the mark, and the sp. gr. determined. This is the "residue gravity" or "extract gravity." The original gravity is obtained by adding the "degrees of gravity lost" to the "residue gravity."

Ex. Sp. gr. of spirit distillate at 60°/60° F. . . 994·10
" " de-alcoholized beer . . 1014·94
("residue gravity")
Spirit indication 1000 − 994·10 = 5·90
5·90 spirit indication = 25·94 "degrees of gravity lost"
"Residue gravity" 1014·94

1040·88 original gravity

Determination of Original Gravity by the Evaporation Process.—In this method the amount of alcohol in a beer is determined from the difference between the sp. gr. of the original beer, freed from its dissolved carbon dioxide, and the sp. gr. of the residue after driving off the alcohol and making up to the original volume, both determinations being made at 60° F. 100 c.c. (or 75 c.c.) are evaporated by gentle boiling in a beaker or basin until the volume is reduced to between one-half and one third, care being taken that none of the solid matter is charred during the process. The cooled residue is transferred back to the measuring flask, the beaker or basin thoroughly rinsed into it, the temperature adjusted to 60°, and made up to the mark. The liquid is then well mixed and its sp. gr. taken. Results are calculated as shown in the example given below.

It has been proved experimentally that the spirit indication obtained as above is 0·16° less than that determined by distillation, the difference being very constant in amount and apparently independent of the actual original gravities of the beers. Hence, by an addition of 0·16° to the spirit indication found, the table on p. 100 may be used for the Evaporation Process also.

Ex. Sp. gr. of original beer at 60° F./60° F. . 1008·64
" evaporated " " . 1014·74
("residue gravity")
6·10
+ ·16
Spirit indication 6·26

From the statutory table 6·26 spirit indication
= 27·32 + ·28 = 27·60 "degrees of gravity lost"
"residue gravity" = 1014·74

1042·34 original gravity.

TABLE FOR SALT IN BEER.

Salt in Grains per Gallon, corresponding to c.c. of Decinormal $AgNO_3$ 25 c.c. of Beer to be employed.*

c.c. $\frac{N}{10}$ $AgNO_3$	Grams NaCl per gallon.	c.c. $\frac{N}{10}$ $AgNO_3$	Grams NaCl per gallon.	c.c. $\frac{N}{10}$ $AgNO_3$	Grains NaCl per gallon.
0·1	1·64	2·2	36·04	4·2	68·80
0·2	3·28	2·3	37·67	4·3	70·43
0·3	4·91	2·4	39·31	4·4	72·07
0·4	6·55	2·5	40·95	4·5	73·71
0·5	8·19	2·6	42·59	4·6	75·35
0·6	9·83	2·7	44·23	4·7	76·99
0·7	11·47	2·8	45·86	4·8	78·62
0·8	13·10	2·9	47·50	4·9	80·26
0·9	14·74	3·0	49·14	5·0	81·90
1·0	16·38	3·1	50·78	5·1	83·54
1·1	18·02	3·2	52·42	5·2	85·18
1·2	19·66	3·3	54·05	5·3	86·81
1·3	21·29	3·4	55·69	5·4	88·45
1·4	22·93	3·5	57·33	5·5	90·09
1·5	24·57	3·6	58·97	5·6	91·73
1·6	26·21	3·7	60·61	5·7	93·37
1·7	27·85	3·8	62·24	5·8	95·00
1·8	29·48	3·9	63·88	5·9	96·64
1·9	31·12	4·0	65·52	6·0	98·28
2·0	32·76	4·1	67·16	6·1	99·92
2·1	34·40				

Note. The above table is useful in giving the amount of NaCl that may be present, calculated from the combined chlorine found. To obtain the actual amount of sodium chloride, the sodium present must also be determined.

* 1 c.c. = 0·00585 gm. NaCl.

BLUNT'S MODIFICATION OF TABARIE'S FORMULA

Tabarie's formula for indirectly determining alcohol in beer and wine from the sp. gr. of the original sample and of the boiled sample made up to the volume taken at the same temperature is

$$\text{sp. gr. of alcohol boiled away} = \frac{S}{S_b}$$

where S = sp. gr. of original liquid
S_b = " boiled " or "extract"

Blunt has shown* that a more correct result is obtained by using the formula

$$\text{sp. gr. of alcohol boiled away} = 1 - (S_b - S)$$
$$= 1 + S - S_b$$

This is fully confirmed by Hehner who found "that in all cases the results obtained by subtraction are closer to those obtained by distillation than are those by Tabarie's formula, and the results are better the greater the alcoholic strength."†

SPECIFIC ROTATORY POWER.

The specific rotatory power of an optically active substance in solution may be defined as the angle through which a plane polarized ray of light of definite refrangibility is rotated by a column one decimetre in length of a solution containing 1 gram of the substance in 1 c.c.

If the rotation is observed through a tube l decimetres in length, and the solution contains c grams of substances in 100 c.c., then, if a be the angle of rotation, the "specific rotatory power" is given by the formula

$$[a] = \frac{a \cdot 100}{l \cdot c}.$$

The ray used and the temperature of the liquid are generally added, thus $[a]_D^{20} = 66{\cdot}6°$ means that the specific rotatory power for ray D ‡ at the temperature of 20° C. is 66·6°.

The specific rotatory power (or "specific rotation") of liquid carbon compounds is given by the formula

$$[a] = \frac{a}{l \cdot d}.$$

Where l is the length of the observation tube in decimetres, d is the sp. gr. of the liquid referred to water at 4° C. as standard, in which case d expresses the weight in grams of 1 c.c.

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* *Analyst*, 1891, **16**, p. 221. † *Ibid.*, p. 223 ‡ Sodium flame.

In this country observations are commonly made at a temperature of 60° F., but on the Continent 20° C. is the "normal temperature" of observation. With many substances, however, a difference of 4·4° C. causes but little difference in the readings.

Molecular Rotation.—This term is applied to the product of the molecular weight (M) and specific rotation of a body divided by 100, and is represented by the symbol [M].

$$[M] = \frac{M}{100}[\alpha]$$

The divisor 100 is used simply to avoid the use of inconveniently large numbers. [M] expresses the rotation which would result if each c.c. of the solution contained 1 gram molecule of the active substance and the length of the liquid column were 1 mm.

Multirotation.—Freshly prepared solutions of a number of the sugars show a rotatory power different from that of the same solution on standing, undergoing either an increase or decrease until finally a constant value is reached. This phenomenon is termed *multirotation* or *mutarotation*.

Originally the term bi-rotation was used, as the observation was made that a dextrose solution when freshly prepared gave about twice the reading of the same solution after standing.

At the ordinary temperature a period of from six to twenty four hours is usually required, but by boiling the transformation to the stable form is completed in a few minutes.* Dextrose, lactose, and maltose show this behaviour, maltose giving with a freshly made solution a *lower* reading than that observed after standing for some hours. Sucrose does not show this effect.

Observations are usually made with a polarimeter, such as Laurent's half-shadow instrument, for which homogeneous light, generally a sodium flame, is required; or with a Soleil-Ventzke Scheibler Colour Saccharimeter, which is adapted for use with white light illumination from oil or gas lamps; or with a modern Half-shadow Saccharimeter,† in which the field of view is divided into two surfaces, each of which alternately becomes perfectly dark as the analyser is rotated, the point sought, and at which the reading is taken, being that at which the two surfaces show exactly the same degree of illumination or partial shadow. White light is used.

Specific rotatory power as determined by the (more or less obsolete) Soleil-Ventzke-Scheibler Colour Saccharimeter is indicated by $[\alpha]_j$, where j is the *transition tint* (*i.e.* from the blue to the red), and is the ray complementary to the medium yellow or *jaune moyen*—hence the j. This *jaune moyen* ray is the true median yellow of the solar spectrum: its wave length is 0·0005608 millimetres.* The Ventzke scale is such that 100 divisions equal the amount of rotation caused by a "normal sugar solution," 200 mm. in length, at 17·5° C. Ventzke proposed a method of preparing this solution which was intended to render the use of a balance unnecessary. He defined the normal sugar solution as a solution of pure sugar in water which should have at 17·5° C. the sp. gr. of 1·100, water at 17·5° being unity. To determine then the polarizing sugar of any substance, it would simply be necessary to prepare a solution of it having this density as shown by a hydrometer. But this method was soon abandoned, because the salts in the cane-sugars to be investigated have a density different from that of sugar itself, and hence cause erroneous results. As, however, the 100 point of many saccharimeters had already been fixed by aid of the normal sugar solution of 1·1 sp. gr., and as it was desirable not to change the scale once introduced, the concentration of the Ventzke normal solution at 17·5° was then determined, and it was found that 100 c.c. of such a solution contained 26·048 grams of sugar: thus the *normal weight* should be 26·048 grams.

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* The same result is also attained by adding a few drops of strong ammonia before making up the volume of the solution.

† In the latest type of polarimeter, the optical field is divided into 3 parts instead of 2, as in the half-shadow instruments. Such instruments are more accurate, the equality of the field being capable of a more delicate adjustment. These "have properly displaced the colour instruments completely: the part of these in saccharimetry has been played, and for good" (Dr. Schonrock).

The above remarks apply only to the original Ventzke instruments. Since 1900 the *normal weight* has been altered to 26·0 grams, and the *normal sugar solution* is prepared as follows.

26 grams of chemically pure dry sugar are dissolved in water at 20° C. in a flask graduated to contain 100 true c.c. The liquid is made up to the mark, well mixed, filtered if necessary, and polarized in a 200 mm. tube at 20° C. The reading should be 100 scale divisions, and each scale-division indicates 0·26 gram of sucrose.

FACTORS FOR THE CONVERSION OF $[\alpha]_D$ INTO $[\alpha]_j$ AND *vice versa*

To convert $[\alpha]_D$ into $[\alpha]_j$ multiply by 1·111 (log. 0·04571) or *add one ninth.*

To convert $[\alpha]_j$ into $[\alpha]_D$, multiply by 0·9 (log. $\bar{1}$·95429) or *subtract one tenth.*

Thus if $[\alpha]_D = 202°$, then $[\alpha]_j = 202 + 22·4 = 224·4°$.
$[\alpha]_j = 57°$, then $[\alpha]_D = 57 - 5·7 = 51·3°$

[Landolt gives $[\alpha]_j = \frac{24·5}{21·72}[\alpha]_D = 1·128\,[\alpha]_D$.

$$[\alpha]_D = \frac{21·72}{24·5}[\alpha]_j = 0·886\,[\alpha]_j.]$$

In the Soleil Ventzke-Scheibler Saccharimeter 100 scale-divisions equal 38·43° for ray j, or

1 scale-division = 0·3843° (log. $\bar{1}$·58467).

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* The wave length of D is 589 $\mu\mu$.

Herzfeld and Schonrock found that at 20° C.,

100 scale divisions Ventzke = 31·657 circular degrees for sodium light;

or scale divisions Ventzke × 0·34657 = circular degrees for sodium light.

Hence 1° angular rotation D = 2·8854 scale-divisions Ventzke.

The values representing specific rotation vary directly as the sp. gr. divisor (D) used. Thus, if 151° be the specific rotation of maltose for $[\alpha]_{3·86}$ (that is, on the basis of the 3·86 divisor), the specific rotation where the divisor 3·92 is used will be $\frac{151 \times 3·92}{3·86} = 153·3°$.

The number of grams per 100 c.c. of a solution of a carbohydrate of which the sp. gr. at 15·5°/15·5° C. is known (water = 1000) is found by dividing the sp. gr. minus 1000 by a divisor (D) given in the subjoined table. (A complete set of divisors for various concentrations is given on p. 113.)

TABLE SHOWING THE SPECIFIC ROTATORY POWERS OF THE PRINCIPAL CARBOHYDRATES IN 10 PER CENT. SOLUTION AT 20° C (= 68° F.).

Substance.	Formula.	Divisor to get grams per 100 c.c.	Specific rotatory power (absolute).		Specific rotatory power reduced to the common divisor 3·86.[1]	
		D	$[\alpha]_D$	$[\alpha]_j$	$[\alpha]_{D\,3·86}$	$[\alpha]_{j\,3·86}$
Sucrose	$C_{12}H_{22}O_{11}$	3·86	+ 66·5	+ 73·8°	+ 66·5°	+ 73·8
Dextrose (d-Glucose)	$C_6H_{12}O_6$	3·82	+ 52·7°	+ 58·6°	+ 53·3	+ 59·2°
Laevulose (d-Fructose)	,,	3·92	− 93·8	104·2	− 92·4°	−102·6°
Invert Sugar	$C_6H_{12}O_6$ + $C_6H_{12}O_6$	3·87	−20·55°	22·8	20·5°	22·7
Maltose	$C_{12}H_{22}O_{11}$	3·92	+ 138°	+ 153·3°	+ 135·9°	+ 150·9°
Dextrin	$(C_6H_{10}O_5)_n$	3·95	+ 200°	+ 222·2	+ 195·4°	+ 217·1°
Lactose (cryst.).	$C_{12}H_{22}O_{11}$ H_2O	3·71	+ 52·5	58·3°	...	...
Lactose (anhyd.)	$C_{12}H_{22}O_{11}$	3·91	+ 55·3°	+ 61·4	...	...

Note. At the meeting of the International Commission for uniting methods of sugar analysis, held in Paris in 1900, the normal temperature of + 20° C. was adopted and all measuring vessels are required to be graduated in true c.c. at this temperature.

[1] According to J. Heron, the common divisor 3·86 gives total solids correctly only in those cases where the sp. gr. of the solution lies between 1036 and 1040. For solutions containing more than 12 grams of solids per 100 c.c. the divisor 3·85 gives closer results.

SOLEIL-VENTZKE-SCHEIBLER SACCHARIMETER 200-MM. TUBE USED: TRANSITION TINT.

1 gram in 100 c.c. of	Scale divisions of deviation at 20° C.†	
	For absolute divisors	For [illegible] factor.
Cane sugar	+ 3·84‡	+ 3·84
Dextrose	+ 3·05	+ 3·08
Laevulose	− 5·42	− 5·34
Invert sugar	− 1·19	− 1·18
Maltose	+ 7·98	+ 7·85
Dextrin	+ 11·56	+ 11·30
Lactose (cryst.)*	+ 3·03	..
„ (anhyd.)	+ 3·20	
Gallisin	...	+ 4·85

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* $C_{12}H_{22}O_{11}.H_2O$.

† The number of scale-divisions is obtained by dividing the [illegible] in each case by 19·215 (log 1·28364).

‡ When inverted this becomes − 1·25

	Multiplier	Logarithm
To convert $C_{12}H_{22}O_{11}$ into $C_{12}H_{24}O_{12}$	$\frac{360·192}{342·176} = 1·053$	0·02228
$C_{12}H_{24}O_{12}$ „ $C_{12}H_{22}O_{11}$	$\frac{342·176}{360·192} = 0·95$	$\bar{1}$·97772
$C_{12}H_{20}O_{10}$ „ $C_{12}H_{24}O_{12}$	$\frac{360·192}{324·16} = 1·111$ or add one-ninth	0·04577
$C_{12}H_{24}O_{12}$ „ $C_{12}H_{20}O_{10}$	$\frac{324·16}{360·192} = 0·9$ or deduct one-tenth	$\bar{1}$·95423

The following examples show the methods employed in solving problems connected with this subject.

Ex. I. To find a formula for calculating the amount of cane-sugar present in a mixture of cane-sugar and dextrose when the specific rotatory power (ray j) before and after inversion are known.

Let R_b be the specific rotatory power before inversion
R_a be the specific rotatory power after inversion
and let x be the percentage of cane-sugar present.

Then $100 - x$ is the percentage of dextrose present.

$$\text{Hence } 100\,R_b = 73{\cdot}8x + (100 - x)\,58{\cdot}6$$
$$\text{and } 100\,R_a = -24{\cdot}0x + (100 - x)\,58{\cdot}6$$
$$\therefore \quad 100(R_b - R_a) = 97{\cdot}8x.$$
$$x = \frac{R_b - R_a}{{\cdot}978}.$$

Similarly when we have given the scale degrees (D) before and after inversion, the 200 mm. tube being used

$$\text{Grams of cane-sugar per 100 c.c. of solution} = \frac{D_b - D_a}{5{\cdot}09}.$$

Ex. II. Determination of cane-sugar in mixtures of cane- and invert-sugar only.

The method now universally adopted is Herzfeld's modification of Clerget's process.* It is carried out as follows: Dissolve the normal weight (26·048 † grams) of the sample to be examined in water and make up to 100 c.c., decolorizing and filtering if necessary, and polarize at 20° C. Transfer 50 c.c. of this solution to a 100-c.c. flask, add 5 c.c. strong (38%) hydrochloric acid and about 20 c.c. of water. Well shake the flask and immerse in a bath of water at the temperature of 70° C., at the same time putting a thermometer in the flask: when the temperature of the sugar solution has reached 68° – 70° C., which it should do in five minutes, the flask is kept in the water-bath at this temperature for five minutes longer, then taken out, cooled down quickly to the normal temperature, diluted with water to 100 c.c., polarized at 20° C., and the reading multiplied by two on account of the dilution of the liquid.

Herzfeld found that pure cane-sugar treated as above showed a change of rotation on a Soleil-Ventzke-Scheibler Saccharimeter of 132·66 divisions at 20° C. Hence –

$$\text{Cane-sugar } \% = \frac{100\,(\text{direct} - \text{inverted reading})^*}{132{\cdot}66}.$$

But, since the algebraical difference here becomes the ***sum of the two readings without regard to sign***, and $100/132{\cdot}66 = 0{\cdot}7539$

$$\text{Cane-sugar } \% = 0{\cdot}7539 \times (\text{sum of readings})$$
$$[\log.\ 0{\cdot}7539 = \bar{1}{\cdot}87729].$$

This method is only applicable when other sugars, inulins, starches, and glucosides, which are also inverted by acids, are not present. When such bodies are present, hydrolysis may be effected by the use of invertase. † Now 26·0 grams.

If, instead of 20° C., the readings before and after inversion are made at $t°$ C.,

$$\text{Cane-sugar } \% = \frac{100(\text{direct} - \text{inverted reading})}{142{\cdot}66 - \frac{t}{2}}.$$

Ex. III. Determination of dextrose and maltose from the cupric reducing power and optical activity (or "opticity") of a solution before and after fermentation.

As an example we may take a commercial "Glucose," which gave the following results:—

Cupric reduction before fermentation	78·85 %
" after "	6·62 "
	72·23
Opticity before fermentation	49·98° $[\alpha]_D$
" after "	11·24° "
	38·71

By fermentation dextrose and maltose are removed, and the differences between the cupric reductions and between the opticities before and after fermentation give a measure of the amounts of the two sugars present. Hence, if D and M be the percentages of dextrose and maltose present respectively, we have (taking 62 as the K of maltose):—

$$62\,M + 100\,D = 7223 \quad (i)$$
$$138\,M + 52{\cdot}7\,D = 3871 \quad (ii)$$

$$(i) \times 138. \quad 8556\,M + 13800\,D = 996774$$
$$(ii) \times 62. \quad 8556\,M + 3267\,D = 240188$$
$$10533\,D = 756586$$
$$D = \frac{756586}{10533} = 71{\cdot}83$$

$$\text{From (i)} \quad 62\,M = 7223 - 7183 = 40$$
$$M = \frac{40}{62} = 0{\cdot}65.$$

Result—Dextrose 71·8 %
Maltose 0·6 "

POLARIMETER READINGS.—REDUCTION OF MINUTES TO DECIMALS OF A DEGREE.

Minutes.	Decimal equivalent.	Minutes.	Decimal equivalent.	Minutes.	Decimal equivalent.	Minutes.	Decimal equivalent.
1	·017	16	·267	31	·517	46	·767
2	·033	17	·283	32	·533	47	·783
3	·05	18	·3	33	·55	48	·8
4	·067	19	·317	34	·567	49	·817
5	083	20	·333	35	·583	50	·833
6	·1	21	·35	36	·6	51	·85
7	·117	22	·367	37	·617	52	867
8	·133	23	·383	38	·633	53	·883
9	·15	24	·4	39	·65	54	·9
10	·167	25	·417	40	·667	55	·917
11	·183	26	·433	41	·683	56	·933
12	·2	27	·45	42	·7	57	·95
13	·217	28	·467	43	·717	58	·967
14	·233	29	·483	44	·733	59	·983
15	·25	30	·5	45	·75		

TABLE GIVING DIVISORS (D) TO GET GRAMS PER 100 C.C. OF CERTAIN SUGAR SOLUTIONS OF KNOWN DENSITY. (H. T. Brown and Edward Jones.)

Sp. gr. at 15·5°/15·5° C.	Sucrose	Dextrose	Laevulose	Invert sugar	Maltose
1005	3·870	3·844	3·942	3·895	3·941
1010	3·869	3·843	3·939	3·891	3·939
1015	3·868	3·841	3·935	3·888	3·936
1020	3·867	3·840	3·932	3·886	3·934
1025	3·866	3·838	3·928	3·883	3·931
1030	3·865	3·836	3·924	3·880	3·929
1035	3·864	3·834	3·921	3·877	3·926
1040	3·863	3·832	3·917	3·874	3·924
1045	3·861	3·829	3·914	3·871	3·921
1050	3·860	3·826	3·910	3·868	3·918
1055	3·858	3·824	3·906	3·865	3·916
1060	3·857	3·821	3·902	3·861	3·913
1065	3·855	3·817	3·899	3·858	3·910
1070	3·854	3·814	3·896	3·855	3·907
1075	3·852	3·810	3·892	3·851	3·905
1080	3·851	3·807	3·888	3·847	[illegible]
1085	3·849	3·803	3·884	3·843	3·899
1090	3·846	3·799	3·880	3·839	3·896
1095	3·844	3·796	3·876	3·836	3·893
1100	3·842	3·792	3·872	3·832	3·890

Note. In the above table the sp. gr. is taken at 15·5° C., and referred to water at the same temperature. To get grams per 100 true c.c. multiply by the factor 0·99802, thus reducing the quantities by about 0·2 per cent.*

Ex. A solution of sucrose of sp. gr. 1030 at 15·5° C. contains 30/3·865 = 7·762 grams of dry sugar in 100 c.c. Hence 100 c.c., which weigh 103 gm., contain 103 − 7·762 = 95·238 gm. of water. The volume of the sugar will be 100 − 95·238 = 4·762 c.c. (taking c.c. to mean the volume occupied by 1 gm. of water at 15·5° C.), and its specific volume (*i.e.* volume occupied by 1 gm.) = 4·762/7·762 = 0·6135 c.c.

Also 1 − 0·6135 = 0·3865, which is one tenth of the original divisor, so that if V = specific volume of the dissolved sugar, D = 10(1 − V) and

$$V = \frac{10 - D}{10}.$$

---

* Thus, the weight of the volume of water at 15·5° C. to which all the densities are referred is 100 grams weighed in air. Reduced to a vacuum this will weigh 100·106 grams, and as the density of water at 15·5° C. is 0·99908 as compared with that of water at 4° C., the true volume of the 100 "reputed" c.c. at 15·5° will be $\frac{100 \cdot 106}{100 \times \cdot 99908}$ = 100·198 c.c. Hence the factor required is $\frac{100}{100 \cdot 198}$ = 0·99802.

CUPRIC OXIDE REDUCING POWERS OF THE CARBOHYDRATES.

Definition.—"Dextrose being the type of reducing bodies and the substance for which the amount of cupric oxide reduced was first determined, I use it as the standard to which to refer all other reducing carbohydrates or mixtures of reducing with non-reducing ones. I take the cupric oxide reducing power (or 'cupric reducing power') of a body or mixture to be the amount of cupric oxide, calculated as dextrose, which 100 parts reduce: it is designated by the letter K."—(*O'Sullivan*).

Briefly, we may define "K" as the specific cupric reducing power of a substance referred to dextrose as standard (100). The divisor is often added: thus $K_{3\cdot86} = 25$ means that the cupric reducing power of the substance is one-fourth that of dextrose when the solid matter is determined by the 3·86 divisor.

Preparation of Fehling's Solution for Gravimetric Determinations.—Dissolve 34·6 grams of pure recrystallized copper sulphate in distilled water and make up the volume to 500 c.c. Then dissolve 173 grams Rochelle salt and 65 grams anhydrous sodium hydroxide in separate beakers, mix the solutions, and make up the volume with distilled water to 500 c.c. These two solutions are kept in separate bottles and are mixed in equal volumes, to form Fehling's solution, immediately before use.

Method of making a determination of cupric reducing power. Fifty c.c. of the freshly mixed Fehling's solution are placed in a beaker of about 250 c.c. capacity, and having a diameter of 7·5 cm. (= 3 inches). This is placed in a boiling water-bath, and when the solution has attained the temperature of the water, the accurately weighed or measured volume of the sugar solution is added, and the whole made up to 100 c.c. with boiling distilled water. The beaker. which is covered with a clock glass, is then returned to the water-bath and the heating continued for exactly twelve minutes. The precipitated cuprous oxide is now rapidly filtered off through a Soxhlet tube, washed first with hot water, then with alcohol and ether, and finally dried. When dry, the cuprous oxide is reduced to metallic copper by gently heating in a stream of hydrogen, and weighed; or it may be oxidized in a stream of oxygen and weighed as CuO. Sometimes the Cu_2O is weighed as such, after being dried in a water oven (see O'Sullivan and Stern, *Jour. Chem. Soc.*, 1896, p. 1692).

As spontaneous reduction of Fehling's solution invariably takes place, the amount of this must be carefully determined for every fresh batch of the solution and allowed for in each determination of cupric reducing power. It usually amounts to 0·002 to 0·003 gram CuO per 50 c.c. of Fehling's solution used.

It is of great importance, in making the above determination, that *an amount of the reducing sugar is taken that will give a weight of CuO lying between* 0·15 *and* 0·35 *gram.*

It must be carefully borne in mind that the values given in the following Tables are correct only when the preparation of the Fehling's solution, and the manner of carrying out the determination of cupric reducing power conform exactly with the direction given on p. 114. It has been shown that the amount and nature of the alkali in Fehling's solution exercises a great influence on the quantity of copper reduced by a given weight of maltose or of the starch-transformation products; but with dextrose and laevulose the influence is far less. Glendinning has proved that an equivalent amount of potassium hydroxide may be substituted for the sodium compound without causing any alteration in the reducing power. In the case of dextrose and laevulose the variant which has the greatest influence is the state of dilution of the Fehling's solution. When the dilution is greater than that prescribed in the standard method, the reducing power is appreciably lower, and the greater the dilution the greater the difference.

The standard conditions given in detail above are those prescribed by Brown, Morris, and Millar and have found wide acceptance. Results are calculated by means of Tables A and B (see pp. 116, 117), both of which are given in their original papers.* Absolute values are given in each case.

The following factors are also useful

			Logarithms
Sucrose (after inversion)	CuO	0·4079	1·6[illegible]
Starch or dextrin (after hydrolysis)	CuO	0·3750	1·57403
Lactose (anhydrous)	CuO	0·5784	1·76223
,, (cryst.)	CuO	0·6088	1·78451
Arabinose	CuO	0·4000	1·60206
Xylose	CuO	0·4167	1·61979

Rules to find the values of "K" when referred to different divisors.

When the true divisor is used to determine grams of sugar per 100 c.c., the K so obtained is called *absolute*. Frequently, however, $K_{3\cdot86}$—that is, the relative cupric reducing power when the divisor 3·86 is used to get grams of sugar per 100 c.c.—is required. Thus 1·372 grams CuO = 1 gram of absolute maltose, then for 1 gram of 3·86 maltose we should have

$$1\cdot372 \times \frac{3\cdot86}{3\cdot92} = 1\cdot351 \text{ gram CuO.}$$

Let the true divisor to get grams per 100 c.c. be M, then

$$K \text{ absolute} = \frac{K_{3\cdot86} \times M}{3\cdot86}.$$

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* See *Journ. Chem. Soc.*, 1897, 71, 72–123 and 275–284.

TABLE A.

Weight of reducing sugar	Dextrose.	Laevulose.	Invert sugar.	Maltose.
	CuO obtained.	CuO obtained.	CuO obtained.	CuO obtained.
mgrms.	grams.	grams.	grams.	grams.
50	0·1289	0·1155	0·1221	...
55	0·1422	0·1287	0·1349	...
60	0·1552	0·1407	0·1474	...
65	0·1682	0·1521	0·1598	...
70	0·1809	0·1645	0·1721	0·0966
75	0·1935	0·1761	0·1840	0·1034
80	0·2061	0·1880	0·1963	0·1102
85	0·2187	0·1993	0·2084	0·1169
90	0·2299	0·2114	0·2200	0·1237
95	0·2420	0·2224	0·2317	0·1305
100	0·2538	0·2331	0·2430	0·1373
105	0·2662	0·2447	0·2550	0·1441
110	0·2781	0·2558	0·2668	0·1509
115	0·2900	0·2669	0·2783	0·1576
120	0·3014	0·2777	0·2898	0·1644
125	0·3133	0·2887	0·3009	0·1712
130	0·3241	0·2997	0·3121	0·1779
135	0·3354	0·3106	0·3232	0·1848
140	0·3463	0·3209	0·3339	0·1916
145	0·3573	0·3311	0·3448	0·1983
150	0·3673	0·3409	0·3546	0·2051
155	0·3787	0·3517	0·3655	0·2119
160	0·3891	0·3622	0·3764	0·2186
165	0·3996	0·3726	0·3869	0·2254
170	0·4098	0·3828	0·3971	0·2323
175	0·4200	0·3930	0·4076	0·2390
180	0·4302	0·4032	0·4177	0·2458
185	0·4399	0·4134	0·4276	0·2526
190	0·4501	0·4231	0·4376	0·2593
195	0·4599	0·4335	0·4476	0·2661
200	0·4689	0·4431	0·4570	0·2729

If Cu is weighed instead of CuO the equivalent amount of the latter is easily obtained, thus: Increase the weight of Cu by one-fourth and then by one-hundredth of the latter, the result is the CuO required, from which the reducing sugar is obtained by the above table.

Ex.

Cu	0·1584
+ ¼th	·0396
+ $\frac{1}{100}$ of ¼th	·0004
	0·1984 CuO,

which corresponds, *e.g.*, to 77 mgrms. of dextrose or 145 mgrms. of maltose.

TABLE B.

Weight of reducing sugar	CuO corresponding to 1 gram of			
	Dextrose	Lævulose.	Invert Sugar	Maltose
mgrms.	grams	grams	grams	grams
50	2·578	[illegible]	2·442	..
55	2·585	[illegible]	[illegible]	..
60	2·587	[illegible]	[illegible]	..
65	2·589	[illegible]	2·459	
70	2·585	[illegible]	[illegible]	[illegible]
75	2·580	[illegible]	[illegible]	1·3796
80	2·577	2·351	[illegible]	1·3792
85	2·572	2·345	2·451	1·3788
90	2·566	2·340	2·445	1·3784
95	[illegible]	[illegible]	2·439	1·3780
100	2·558	2·331	2·430	1·3777
105	2·535	[illegible]	[illegible]	1·3773
110	2·528	[illegible]	[illegible]	1·3769
115	2·522	2·321	[illegible]	1·3765
120	2·512	2·311	2·415	1·3761
125	[illegible]	[illegible]	2·407	[illegible]
130	[illegible]	[illegible]	[illegible]	[illegible]
135	2·484	2·300	2·394	[illegible]
140	[illegible]	2·292	2·385	1·3746
145	2·461	2·281	2·378	1·3742
150	2·448	[illegible]	2·364	1·3738
155	[illegible]	[illegible]	[illegible]	[illegible]
160	2·432	2·261	2·352	1·3731
165	2·422	2·258	2·345	1·3727
170	2·410	2·252	2·336	1·3723
175	2·400	2·245	2·329	1·3719
180	2·390	2·240	2·320	1·3715
185	2·377	[illegible]	2·311	1·3711
190	2·369	[illegible]	2·303	1·3708
195	2·358	[illegible]	2·295	1·3704
200	2·341	2·216	[illegible]	1·3700

Ex. Suppose that in a determination of dextrose 0·2900 gram of CuO was obtained. From Table A we find that this amount equals 115 mgrms of dextrose; and by Table B, in the column giving dextrose, the figures 2·522 opposite 115 mgrms. show that 2·522 grams of CuO correspond to 1 gram of dextrose.

The following volumetric method, due to Ling and Rendle, is claimed to be quite as accurate as the gravimetric method already described and has the advantage of being far more rapid. The average error is 1 part in 300.

Fehling's solution is used and is made as follows:—

Solution No. 1.—Dissolve 69·28 grams of pure copper sulphate crystals in water and make up to 1 litre.

Solution No. 2.—316 grams of Rochelle salt are dissolved in hot water, 142 grams of caustic soda dissolved separately, the two solutions mixed in a litre flask, cooled and made up to the mark.

Equal volumes of these two solutions are accurately measured out at 15·5° C., and mixed in a dry flask immediately before use. The mixture constitutes the solution from which measured quantities are taken for titration.

The indicator is prepared as follows: 1·5 grams of ammonium thiocyanate and 1 gram of ferrous ammonium sulphate are dissolved in 10 c.c. of water, 2·5 c.c. of conc. hydrochloric acid added, and the solution decolorized by the cautious addition of zinc dust. The indicator when kept for some time again develops the red (ferric) colour due to atmospheric oxidation, and must again be reduced. When decolorized too often in this way, the indicator loses sensitiveness.

Method of Procedure.—10 c.c. of Fehling's solution are pipetted into a 200 c.c. boiling flask and raised to boiling. The sugar solution, which should be adjusted to such a strength that 20 to 30 c.c. of it are required to reduce 10 c.c. of Fehling's solution, is then run into the boiling (undiluted) liquid in small amounts, commencing with 5 c.c. After each addition of sugar solution the mixture is boiled, the liquid being kept rotated. About a dozen drops of the indicator are placed on a white porcelain plate, and when it is judged that the precipitation of cuprous oxide is complete, a drop of the liquid is withdrawn by a glass rod or a capillary tube, and brought into contact with a drop of the indicator on the plate. The test must be carried out rapidly. The titration must be performed as rapidly as possible, as an atmosphere of steam is then kept in the neck of the flask and the influence of atmospheric oxygen avoided. At the final point, the liquid is boiled for about ten seconds. The first titration may give only an approximate result, and a second or third be necessary to establish the end-point accurately. One titration takes from 2½ to 3 minutes. The titration can be carried out by artificial light (incandescent gas or electric light).

The Fehling's solution is standardized as follows: Dissolve 0·95 gram of pure sucrose in water (150 c.c.), add 30 c.c. of N/2 HCl, and boil the mixture for one minute. Cool, add 30 c.c. N/2 sodium hydroxide solution and make up with water to 500 c.c. This solution, which contains 0·2 gram of invert sugar per 100 c.c., is then titrated with 10 c.c. portions of Fehling's solution as above. (About 25·5 c.c. of the former solution will be required.) The value of the solution in terms of dextrose, maltose, etc., is determined in a similar manner.* Every preparation of Fehling's solution will need standardizing. Results are calculated by the following table.

LING AND JONES'S TABLE FOR USE WITH FEHLING'S SOLUTION.

Volume of sugar solution required by 10 c.c. of Fehling's solution.	Dextrose. D. Dextrose in 100 c.c. of solution.	Dextrose. D′. Fehling's solution equivalent to 1 gm. of dextrose.	Laevulose. L. Laevulose in 100 c.c. of solution.	Laevulose. L′. Fehling's solution equivalent to 1 gm. of laevulose.	Invert Sugar. I. Invert sugar in 100 c.c. of solution.	Invert Sugar. I′. Fehling's solution equivalent to 1 gm. of invert sugar.	Maltose. M. Maltose in 100 c.c. of solution.	Maltose. M′. Fehling's solution equivalent to 1 gm. maltose.
c.c.	gram.	c.c.	gram.	c.c.	gram	c.c.	gram	c.c.
20	0·2427	206·0	...	...	...	...	...	...
21	0·2332	205·1	...	...	0·2412	197·5	0·3888	122·5
22	0·2226	204·2	0·2411	188·5	0·2311	196·8	0·3711	...
23	0·2138	203·4	0·2312	188·0	0·2218	196·0	0·3550	...
24	0·2056	202·6	0·2222	187·5	0·2132	195·5	0·3402	A constant
25	0·1981	201·9	0·2138	187·1	0·2052	194·9	0·3266	
26	0·1911	201·3	0·2060	186·7	0·1980	194·3	0·3140	
27	0·1846	200·7	0·1988	186·3	0·1910	193·9	0·3023	
28	0·1784	200·1	0·1921	186·0	0·1846	193·4	0·2915	
29	0·1728	199·6	0·1857	185·6	0·1787	193·0	0·2815	
30	0·1675	199·1	0·1798	185·1	0·1731	192·5	0·2721	
31	0·1625	198·6	0·1743	185·1	0·1678	192·2	0·2633	
32	0·1577	198·2	0·1691	184·8	0·1629	191·8	0·2551	
33	0·1532	197·8	0·1642	184·6	0·1583	191·5	0·2474	
34	0·1490	197·4	0·1596	184·3	0·1539	191·2	0·2401	
35	0·1450	197·0	0·1552	184·1	0·1497	190·9	0·2332	
36	0·1412	196·7	0·1511	183·9	0·1458	190·6	0·2268	...
37	0·1377	196·4	0·1472	183·6	0·1421	190·3	0·2206	...
38	0·1343	196·0	0·1435	183·4	0·1385	190·1	0·2148	...
39	0·1310	195·8	0·1399	183·3	0·1349	189·8	0·2093	...
40	0·1279	195·5	0·1366	183·1	0·1319	189·6	0·2041	122·5
41	...	...	0·1334	182·9	0·1288	189·4	...	...
42	...	...	0·1298	182·8	0·1259	189·2	...	...
43	...	...	0·1274	182·6	...	...	...	...

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[1] See *The Analyst*, 1908, 33, 165. The table was constructed on the basis of a preparation of Fehling's solution of which 10 c.c. required 25·65 c.c. of a 0·2 per cent. solution of invert sugar.

Examples showing the use of the above table.

(i) Suppose that 25·0 c.c. of a solution of pure laevulose are required to reduce 10 c.c. of Fehling's solution. The figure in the column under L and opposite 25, viz. 0·2138, gives the grams of laevulose in 100 c.c. of the solution.

(ii) Suppose that for 10 c.c. of Fehling's solution 32·7 c.c. of a solution of pure dextrose are required. Then the grams of dextrose in 100 c.c. of the solution will be

$$0{\cdot}1577-({\cdot}1577-{\cdot}1532)\times{\cdot}7=0{\cdot}1577-0{\cdot}0032=0{\cdot}1544.$$

(iii) The numbers given in columns D′, L′, I′, and M′ are used when separate determinations of two reducing sugars in a mixture, *e.g.* commercial invert sugar, are required. In these cases polarimetric observations are necessary, in addition to the determination of cupric-reducing power. A fully worked-out example of the calculation of percentages of dextrose and laevulose respectively from data so obtained is given in *The Analyst*, 1908, 33 166 *et seq.*

ALCOHOLOMETRY.

Alcoholometry is the process of determining the strength of alcohol or the percentage of absolute alcohol in a spirituous mixture.

The following Table, which is believed to be the most accurate in existence, is a shortened form * of that compiled by Mr T. J. Cheater and Mr John Holmes, of the Government Laboratory, London, under the direction of Sir Edward Thorpe, F.R.S., who was then its Principal. In it are incorporated the results of the researches of four authorities, viz., Mendeléeff (1865), whose work "admittedly constitutes the most comprehensive and exact of the researches hitherto made in the field of alcoholometry"; Blagden and Gilpin (1790 91); Drinkwater (1848); and the Kaiserliche Normal Eichungs Kommission (Berlin, 1889). The basis of the Table is Mendeléeff's alcohol of sp. gr. 0·79359 at 15·6°/15·6° C. in air.

Proof Spirit.—In the assessment of duty and in commercial transactions the standard of strength is termed "proof." Spirit of proof strength is defined by statute (58 Geo. III c. 28) as "that which at a temperature of 51° F. weighs exactly $\frac{12}{13}$ths of an equal measure of distilled water" also at 51° F. The sp. gr. of proof spirit at 60° F./60° F. is 0·91976, and it contains 49·28 per cent. by weight and 57·10 per cent. by volume of anhydrous (or absolute) alcohol. Spirits of higher alcoholic content are said to be of overproof strength (o.p.) and those of lower alcoholic content of underproof strength (u.p.).

To find percentage of proof spirit:

(*a*) In spirits of overproof strength: add 100 to the percentage overproof, thus:

Sp. gr. 0·8120 = 68·28 per cent. o.p. and contains 168·28 per cent. of proof spirit. 100 vols. of this spirit, when diluted with water, will give 168·28 vols. of proof spirit.

(*b*) In spirits of underproof strength: subtract the percentage underproof from 100, thus:

Sp. gr. 0·9615 = 42·00 per cent. u.p. and contains 100 − 42 = 58 per cent. of proof spirit.

American proof spirit is defined as containing one half of its volume of Tralles's alcohol at 15·6° C. The latter has the sp. gr. 0·7946 at 15·6°/15·6° C. But as the American gallon is only $\frac{5}{6}$ths of the British gallon, 100 British proof gallons are equal to 137 American proof gallons.

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* For the full table, proceeding by 0·0002 sp. gr., see *Alcoholometric Tables*, by Sir E. Thorpe (Longmans, Green & Co.).

ALCOHOLOMETRIC TABLE

Sp. gr. at 60° F./60° F.	Percentage of alcohol		Per cent. over proof	Sp. gr. at 60° F./60° F.	Percentage of alcohol		Per cent. over proof.
	By weight	By volume			By weight	By volume	
0·79359	100·00	100·00	75·25	0·8145	92·90	95·35	67·19
·7940	99·87	99·92	75·21	·8150	92·72	95·22	66·96
·7945	99·71	99·82	75·04	·8155	92·54	95·10	66·73
·7950	99·55	99·72	74·87	·8160	92·36	94·97	66·51
·7955	99·39	99·62	74·70	·8165	92·18	94·84	66·29
·7960	99·22	99·52	74·52	·8170	92·00	94·71	66·06
·7965	99·06	99·42	74·34	·8175	91·82	94·58	65·83
·7970	98·90	99·32	74·16	·8180	91·63	94·45	65·60
·7975	98·74	99·22	73·98	·8185	91·45	94·32	65·37
·7980	98·57	99·12	73·80	·8190	91·27	94·19	65·14
·7985	98·41	99·02	73·62	·8195	91·08	94·06	64·91
·7990	98·24	98·91	73·44	·8200	90·90	93·92	64·67
·7995	98·08	98·81	73·26	·8205	90·71	93·79	64·44
·8000	97·91	98·70	73·07	·8210	90·53	93·65	64·20
·8005	97·75	98·60	72·89	·8215	90·35	93·52	63·96
·8010	97·59	98·49	72·71	·8220	90·16	93·38	63·72
·8015	97·42	98·39	72·52	·8225	89·97	93·25	63·48
·8020	97·25	98·28	72·34	·8230	89·79	93·11	63·24
·8025	97·08	98·17	72·14	·8235	89·60	92·97	63·00
·8030	96·91	98·06	71·95	·8240	89·41	92·83	62·75
·8035	96·74	97·95	71·76	·8245	89·22	92·69	62·51
·8040	96·57	97·84	71·56	·8250	89·03	92·55	62·26
·8045	96·40	97·73	71·37	·8255	88·84	92·41	62·01
·8050	96·23	97·62	71·17	·8260	88·65	92·26	61·76
·8055	96·06	97·51	70·97	·8265	88·46	92·12	61·51
·8060	95·89	97·39	70·77	·8270	88·27	91·98	61·26
·8065	95·72	97·28	70·57	·8275	88·08	91·84	61·01
·8070	95·55	97·16	70·37	·8280	87·88	91·69	60·75
·8075	95·38	97·05	70·17	·8285	87·69	91·55	60·50
·8080	95·20	96·93	69·96	·8290	87·50	91·40	60·24
·8085	95·03	96·81	69·76	·8295	87·31	91·26	59·99
·8090	94·85	96·69	69·55	·8300	87·11	91·11	59·73
·8095	94·68	96·57	69·34	·8305	86·92	90·97	59·47
·8100	94·50	96·45	69·13	·8310	86·73	90·82	59·21
·8105	94·33	96·33	68·93	·8315	86·54	90·67	58·95
·8110	94·15	96·21	68·71	·8320	86·34	90·52	58·69
·8115	93·98	96·09	68·50	·8325	86·15	90·37	58·43
·8120	93·80	95·97	68·28	·8330	85·95	90·22	58·16
·8125	93·62	95·85	68·07	·8335	85·76	90·07	57·90
·8130	93·44	95·72	67·86	·8340	85·56	89·91	57·63
·8135	93·26	95·60	67·64	·8345	85·37	89·76	57·37
·8140	93·08	95·47	67·41	·8350	85·17	89·61	57·10

ALCOHOLOMETRIC TABLE—*continued.*

Sp. gr. at 60° F./60° F.	Percentage of alcohol.		Per cent. *over* proof.	Sp. gr. at 60° F./60° F.	Percentage of alcohol.		Per cent. *over* proof.
	By weight.	By volume.			By weight.	By volume.	
0·8355	84·98	89·46	56·83	0·8565	76·51	82·56	44·71
·8360	84·78	89·30	56·56	·8570	76·30	82·38	44·40
·8365	84·59	89·15	56·29	·8575	76·09	82·21	44·09
·8370	84·39	88·99	56·02	·8580	75·88	82·03	43·78
·8375	84·19	88·84	55·75	·8585	75·68	81·86	43·47
·8380	83·99	88·68	55·47	·8590	75·47	81·68	43·16
·8385	83·80	88·53	55·20	·8595	75·26	81·50	42·85
·8390	83·60	88·37	54·92	·8600	75·05	81·32	42·54
·8395	83·40	88·22	54·65	·8605	74·85	81·15	42·23
·8400	83·20	88·06	54·37	·8610	74·64	80·97	41·91
·8405	83·00	87·90	54·09	·8615	74·43	80·79	41·60
·8410	82·80	87·74	53·81	·8620	74·22	80·61	41·28
·8415	82·60	87·58	53·53	·8625	74·02	80·43	40·97
·8420	82·40	87·42	53·25	·8630	73·81	80·25	40·65
·8425	82·20	87·25	52·97	·8635	73·60	80·07	40·34
·8430	82·00	87·09	52·68	·8640	73·39	79·89	40·02
·8435	81·80	86·93	52·40	·8645	73·18	79·71	39·70
·8440	81·60	86·77	52·12	·8650	72·97	79·53	39·38
·8445	81·40	86·61	51·84	·8655	72·76	79·35	39·06
·8450	81·20	86·44	51·55	·8660	72·55	79·16	38·74
·8455	81·00	86·28	51·26	·8665	72·35	78·98	38·42
·8460	80·79	86·12	50·97	·8670	72·14	78·80	38·10
·8465	80·59	85·96	50·68	·8675	71·93	78·62	37·78
·8470	80·39	85·80	50·39	·8680	71·72	78·43	37·46
·8475	80·19	85·63	50·10	·8685	71·51	78·25	37·14
·8480	79·98	85·46	49·80	·8690	71·30	78·06	36·81
·8485	79·78	85·29	49·51	·8695	71·09	77·88	36·49
·8490	79·58	85·12	49·21	·8700	70·88	77·69	36·16
·8495	79·38	84·95	48·92	·8705	70·67	77·51	35·83
·8500	79·17	84·78	48·62	·8710	70·46	77·32	35·50
·8505	78·97	84·61	48·33	·8715	70·25	77·13	35·17
·8510	78·76	84·44	48·03	·8720	70·04	76·94	34·84
·8515	78·56	84·28	47·73	·8725	69·83	76·76	34·52
·8520	78·35	84·11	47·43	·8730	69·62	76·57	34·19
·8525	78·15	83·94	47·13	·8735	69·41	76·38	33·86
·8530	77·94	83·77	46·83	·8740	69·19	76·19	33·53
·8535	77·74	83·60	46·53	·8745	68·98	76·01	33·20
·8540	77·53	83·42	46·23	·8750	68·77	75·82	32·86
·8545	77·33	83·25	45·93	·8755	68·56	75·63	32·53
·8550	77·12	83·08	45·62	·8760	68·35	75·44	32·19
·8555	76·92	82·91	45·32	·8765	68·14	75·25	31·86
·8560	76·71	82·73	45·01	·8770	67·93	75·06	31·53

Alcoholometric Table—*continued*.

Sp. gr. at 60° F./60° F.	Percentage of alcohol.		Per cent. *over* proof	Sp. gr. at 60° F./60° F.	Percentage of alcohol.		Per cent. *over* proof.
	By weight.	By volume			By weight.	By volume	
0·8775	67·73	74·87	31·29	0·8990	58·50	66·25	16·07
·8780	67·51	74·68	30·86	·8995	58·28	66·04	15·80
·8785	67·30	74·49	30·52	·9000	58·06	65·83	15·33
·8790	67·09	74·30	30·18	·9005	57·84	65·63	14·96
·8795	66·88	74·11	29·84	·9010	57·62	65·41	14·59
·8800	66·66	73·92	29·50	·9015	57·40	65·20	14·22
·8805	66·45	73·72	29·16	·9020	57·18	64·98	13·84
·8810	66·24	73·52	28·82	·9025	56·97	64·77	13·47
·8815	66·03	73·33	28·48	·9030	56·75	64·56	13·10
·8820	65·81	73·13	28·14	·9035	56·53	64·35	12·73
·8825	65·60	72·94	27·80	·9040	56·31	64·13	12·35
·8830	65·39	72·74	27·46	·9045	56·09	63·92	11·97
·8835	65·18	72·54	27·11	·9050	55·87	63·70	11·59
·8840	64·96	72·34	26·77	·9055	55·65	63·48	11·21
·8845	64·75	72·14	26·42	·9060	55·42	63·26	10·82
·8850	64·53	71·95	26·07	·9065	55·20	63·05	10·44
·8855	64·32	71·75	25·73	·9070	54·98	62·83	10·06
·8860	64·10	71·55	25·38	·9075	54·76	62·61	9·68
·8865	63·89	71·35	25·02	·9080	54·54	62·39	9·29
·8870	63·67	71·15	24·67	·9085	54·32	62·17	8·91
·8875	63·46	70·95	24·32	·9090	54·10	61·95	8·52
·8880	63·24	70·75	23·97	·9095	53·88	61·73	8·13
·8885	63·03	70·55	23·62	·9100	53·65	61·51	7·74
·8890	62·81	70·35	23·27	·9105	53·43	61·29	7·36
·8895	62·60	70·15	22·92	·9110	53·21	61·07	6·97
·8900	62·38	69·95	22·56	·9115	52·99	60·85	6·59
·8905	62·17	69·75	22·21	·9120	52·77	60·63	6·20
·8910	61·95	69·55	21·85	·9125	52·55	60·41	5·81
·8915	61·74	69·35	21·50	·9130	52·33	60·19	5·42
·8920	61·52	69·14	21·14	·9135	52·11	59·97	5·03
·8925	61·31	68·94	20·78	·9140	51·88	59·75	4·63
·8930	61·09	68·74	20·42	·9145	51·66	59·52	4·24
·8935	60·88	68·54	20·06	·9150	51·43	59·29	3·84
·8940	60·66	68·33	19·70	·9155	51·21	59·06	3·45
·8945	60·45	68·13	19·34	·9160	50·98	58·83	3·05
·8950	60·23	67·92	18·98	·9165	50·76	58·61	2·65
·8955	60·02	67·71	18·62	·9170	50·53	58·38	2·24
·8960	59·80	67·50	18·26	·9175	50·31	58·15	1·84
·8965	59·59	67·29	17·90	·9180	50·08	57·92	1·43
·8970	59·37	67·08	17·54	·9185	49·86	57·69	1·03
·8975	59·15	66·88	17·18	·9190	49·63	57·46	0·62
·8980	58·93	66·67	16·81	·9195	49·40	57·23	0·21
·8985	58·72	66·46	16·44	·91976	49·28	57·10	Proof

ALCOHOLOMETRIC TABLE—*continued*.

Sp. gr. at 60° F., 60° F.	Percentage of alcohol.		Per cent. *under* proof.	Sp. gr. at 60° F., 60° F.	Percentage of alcohol.		Per cent. *under* proof.
	By weight.	By volume.			By weight.	By volume.	
0·9200	49·17	56·99	0·20	0·9410	39·15	46·40	18·77
·9205	48·94	56·76	0·61	·9415	38·90	46·13	19·26
·9210	48·71	56·52	1·02	·9420	38·64	45·85	19·74
·9215	48·48	56·29	1·43	·9425	38·38	45·57	20·24
·9220	48·25	56·05	1·84	·9430	38·12	45·28	20·74
·9225	48·02	55·82	2·25	·9435	37·86	45·00	21·24
·9230	47·79	55·58	2·67	·9440	37·60	44·71	21·74
·9235	47·56	55·34	3·09	·9445	37·34	44·42	22·25
·9240	47·33	55·10	3·51	·9450	37·07	44·13	22·76
·9245	47·10	54·86	3·93	·9455	36·81	43·84	23·28
·9250	46·87	54·62	4·35	·9460	36·54	43·54	23·79
·9255	46·64	54·38	4·77	·9465	36·27	43·25	24·31
·9260	46·40	54·14	5·20	·9470	36·00	42·95	24·83
·9265	46·17	53·90	5·63	·9475	35·73	42·65	25·36
·9270	45·94	53·65	6·05	·9480	35·46	42·35	25·88
·9275	45·71	53·41	6·48	·9485	35·19	42·05	26·42
·9280	45·47	53·16	6·91	·9490	34·92	41·74	26·95
·9285	45·24	52·92	7·34	·9495	34·65	41·44	27·49
·9290	45·00	52·67	7·77	·9500	34·37	41·13	28·02
·9295	44·77	52·43	8·21	·9505	34·09	40·82	28·58
·9300	44·53	52·18	8·64	·9510	33·81	40·50	29·13
·9305	44·30	51·93	9·08	·9515	33·53	40·19	29·69
·9310	44·06	51·68	9·51	·9520	33·25	39·87	30·24
·9315	43·83	51·43	9·95	·9525	32·96	39·55	30·81
·9320	43·59	51·18	10·39	·9530	32·67	39·22	31·38
·9325	43·35	50·93	10·84	·9535	32·38	38·90	31·95
·9330	43·11	50·67	11·29	·9540	32·09	38·57	32·52
·9335	42·87	50·41	11·74	·9545	31·80	38·23	33·12
·9340	42·62	50·15	12·19	·9550	31·50	37·89	33·71
·9345	42·38	49·89	12·65	·9555	31·20	37·55	34·31
·9350	42·13	49·63	13·11	·9560	30·90	37·20	34·91
·9355	41·89	49·37	13·57	·9565	30·59	36·85	35·53
·9360	41·64	49·10	14·03	·9570	30·28	36·50	36·15
·9365	41·40	48·84	14·50	·9575	29·97	36·15	36·78
·9370	41·15	48·57	14·96	·9580	29·66	35·79	37·40
·9375	40·90	48·31	15·43	·9585	29·35	35·43	38·04
·9380	40·65	48·04	15·90	·9590	29·03	35·06	38·68
·9385	40·40	47·77	16·38	·9595	28·71	34·70	39·33
·9390	40·15	47·50	16·85	·9600	28·39	34·33	39·97
·9395	39·90	47·23	17·33	·9605	28·06	33·95	40·65
·9400	39·65	46·95	17·81	·9610	27·73	33·56	41·32
·9405	39·40	46·68	18·29	·9615	27·40	33·18	42·00

ALCOHOLOMETRIC TABLE—*continued.*

Sp. gr. at 60 F./60 F.	Percentage of alcohol		Per cent *under* proof.	Sp. gr. at 60 F./60 F.	Percentage of alcohol		Per cent *under* proof
	By weight	By volume			By weight	By volume	
0·9620	27·06	32·79	42·77	0·9810	12·20	15·08	73·68
·9625	26·72	32·39	43·47	·9815	11·81	14·61	74·51
·9630	26·37	31·99	[illegible]	·9820	11·42	14·15	75·34
·9635	26·03	31·59	[illegible]	·9825	11·04	13·67	76·16
·9640	25·68	31·18	[illegible]	·9830	10·65	13·20	76·97
·9645	25·33	30·76	[illegible]	·9835	10·28	12·75	77·77
·9650	24·97	30·33	46·96	·9840	9·92	12·29	78·56
·9655	24·60	29·91	47·72	·9845	9·55	11·85	79·35
·9660	24·23	29·48	48·47	·9850	9·18	11·40	80·13
·9665	23·86	29·04	49·25	·9855	8·82	10·96	80·90
·9670	23·48	28·60	50·02	·9860	8·46	10·51	81·66
·9675	23·10	28·15	50·82	·9865	8·11	10·08	82·41
·9680	22·71	27·69	51·62	·9870	7·76	9·65	83·15
·9685	22·32	27·23	52·43	·9875	7·42	9·23	83·89
·9690	21·93	26·77	53·23	·9880	7·08	8·80	84·62
·9695	21·54	26·30	54·05	·9885	6·75	8·39	85·34
·9700	21·14	25·83	54·86	·9890	6·41	7·98	86·06
·9705	20·74	25·34	55·70	·9895	6·09	7·58	86·77
·9710	20·34	24·85	56·55	·9900	5·76	7·18	87·47
·9715	19·94	24·38	57·38	·9905	5·45	6·79	88·16
·9720	19·53	23·91	58·22	·9910	5·13	6·40	88·84
·9725	19·13	23·43	59·09	·9915	4·82	6·02	89·51
·9730	18·72	22·94	59·94	·9920	4·51	5·63	90·18
·9735	18·31	22·45	60·80	·9925	4·21	5·26	90·84
·9740	17·90	21·96	61·65	·9930	3·90	4·88	91·49
·9745	17·49	21·47	62·52	·9935	3·61	4·51	92·13
·9750	17·08	20·97	63·38	·9940	3·31	4·14	92·76
·9755	16·67	20·48	64·26	·9945	3·02	3·78	93·39
·9760	16·25	19·98	65·13	·9950	2·73	3·42	94·02
·9765	15·84	19·49	65·99	·9955	2·45	3·07	94·65
·9770	15·43	18·99	66·86	·9960	2·17	2·71	95·27
·9775	15·02	18·50	67·72	·9965	1·89	2·37	95·88
·9780	14·61	18·00	68·58	·9970	1·61	2·02	96·48
·9785	14·21	17·51	69·44	·9975	1·34	1·68	97·08
·9790	13·80	17·02	70·30	·9980	1·07	1·34	97·67
·9795	13·40	16·53	71·16	·9985	0·80	1·00	98·26
·9800	12·99	16·04	72·01	·9990	0·53	0·66	98·84
·9805	12·60	15·56	72·85	·9995	0·26	0·33	99·42

FORMULÆ FOR THE CONVERSION OF DIFFERENT STATEMENTS OF ALCOHOLIC STRENGTH.

Let S = sp. gr. at 60° F./60° F.
$\%$ = grams of absolute alcohol per 100 grams.
v/v = c.c. " " " 100 c.c.
w/v = grams " " " 100 c.c.
P = c.c. of proof spirit per 100 c.c.

And using c.c. to indicate the volume occupied by 1 gram of water at 60° F. ("reputed" c.c.).

Then
$$\% = \frac{0{\cdot}7936\ v/v}{S} = \frac{w/v}{S} = \frac{0{\cdot}45326\ P}{S}.$$
$$v/v = \% \times 1{\cdot}2601\ S = 1{\cdot}2601\ w/v = 0{\cdot}5710\ P.$$
$$w/v = \% \times S = 0{\cdot}7936\ v/v = 0{\cdot}45326\ P.$$
$$P = \% \times 2{\cdot}2063\ S = 1{\cdot}751\ v/v = 2{\cdot}2063\ w/v.$$

The methods of obtaining the above formulæ are illustrated by the two examples given below.

To find a formula to convert percentage by volume (v/v) into percentage by weight (%).

100 c.c. of alcohol whose sp. gr. at 60° F./60° F. is S weigh 100 S grams and contain v c.c. of absolute alcohol.

That is, 100 S grams contain v c.c. of absolute alcohol.

$$\therefore\ 100 \text{ grams } ,, \quad \frac{v}{S} \text{ c.c.} \quad ,, \quad ,,$$

But 1 c.c. of absolute alcohol weighs 0·7936 gram.

$$\therefore\ \frac{v}{S} \text{ c.c. weigh } \frac{v \times 0{\cdot}7936}{S} \text{ grams.}$$

That is, 100 grams contain $\frac{v \times 0{\cdot}7936}{S}$ grams of absolute alcohol,

$$\text{or } \% = \frac{v/v \times 0{\cdot}7936}{S}.$$

Similarly, to find the factor in the case of proof spirit.

Here 100 c.c. contain P c.c. of proof spirit—that is, 100 S grams contain P c.c. of proof spirit.

But 1 c.c. of proof spirit weighs 0·91976 gram and 1 gram of proof spirit contains 0·4928 gram of absolute alcohol.

∴ 1 c.c. of proof spirit contains $0{\cdot}91976 \times {\cdot}4928 = 0{\cdot}45326$ grams of absolute alcohol.

Therefore 100 S grams of the given alcohol contain $0{\cdot}45326 \times P$ grams of absolute alcohol.

That is, 100 grams contain $\frac{0{\cdot}45326\ P}{S}$ grams of absolute alcohol

$$\text{or } \% = \frac{0{\cdot}45326\ P}{S}.$$

CORRECTION OF SPECIFIC GRAVITY OF DILUTE ALCOHOL FOR TEMPERATURE.

Specific Gravity.	1° Fah.	1° C.	Specific Gravity.	1° Fah.	1° C.
·794–·861	0·00046	0·00083	·965–·966	0·00026	0·00047
·864–·889	45	81	·966–·967	25	45
·889–·902	44	79	·967–·968	24	43
·902–·912	43	77	·968–·969	23	41
·912–·921	42	76	·969–·970	22	40
·921–·928	41	73	·970–·971	21	38
·928–·935	40	72	·971–·973	20	36
·935–·940	39	70	·973–·974	19	34
·940–·943	38	68	·974–·975	18	32
·943–·946	37	67	·975–·976	17	31
·946–·949	36	65	·976–·977	16	29
·949–·951	35	63	·977–·978	15	27
·951–·953	34	61	·978–·980	14	25
·953–·955	33	59	·980–·981	13	23
·955–·957	32	58	·981–·983	12	22
·957–·959	31	56	·983–·985	11	20
·959–·961	30	54	·985–·987	10	18
·961–·962	29	52	·987–·990	0009	16
·962–·963	28	50	·990–·995	8	14
·963–·965	27	49	·995–1·000	7	13

Rule.—To obtain correct sp. gr. at 60° Fah. (= 15·5° C.), multiply the factor given in the table opposite to the observed sp. gr. by the difference in temperature, and *add* if the recorded temperature is *above* 60° F., or *subtract* if it is *below* 60°.

Ex.—The sp. gr. at 60° Fah. of dilute alcohol of sp. gr. 0·952 at 64° Fah. is 0·952 + (0·00034 × 4) = 0·95336.

RULES FOR DILUTION OF ALCOHOL.

Find in every case what fraction of strength the weaker spirit is of the stronger in terms of proof spirit, and thence obtain the quantity of the stronger spirit to be diluted to produce the required amount of the weaker spirit.

Ex. 1. To make 20 gallons of spirit 20 u.p. from spirit 25 o.p.

Spirit 20 u.p. contains 80 per cent. of proof spirit.
25° o.p. „ 125 „

Hence the fraction is $\frac{80}{125} = \frac{16}{25}$, and the amount of the stronger spirit required is $\frac{16}{25} \times 20 = 12·8$ gallons, or 12 gallons 3 quarts 8 fl. ounces. This is carefully diluted with water till the mixture measures 20 gallons.

(80 vols. of the above strong spirit diluted to 125 vols. will give spirit 20° u.p.)

Ex. 2. To make 20 gallons of spirit 30° o.p. from spirit 60° o.p.

Here the fraction is $\frac{130}{160} = \frac{13}{16}$, and $\frac{13}{16} \times 20 = 16\frac{1}{4}$.

Hence $16\frac{1}{4}$ gallons, or 16 gallons 1 quart of the stronger spirit must be diluted to 20 gallons.

(130 vols. of the stronger spirit diluted to 160 vols. will give spirit 30° o.p.)

Approximations.— In technical operations it is frequently required to know what proportion of water must be added to spirit in order to reduce its strength by a given amount. In this case the contraction that takes place when spirit and water are mixed is disregarded, and the calculation is based on the principle that the volume is inversely as the strength. The volume which the reduced spirit will have is calculated, and the difference between this and the original volume is taken as the volume of (distilled) water to be added.

Ex. How much water is required to reduce 60 gallons of spirit at 10° o.p. to 5° o.p.?

10° o.p. = 110 per cent. of proof spirit.
„ 5° o.p. = 105 „ „

Hence volume of reduced spirit will be,

$$60 \times \frac{110}{105} = 62{\cdot}9 \text{ gallons.}$$

and the volume of water to be added is 62·9 − 60 = 2·9 gallons.

Distillation of Spirits. —In determining spirit strengths by distillation it should be noted that, while it is possible to distil without loss spirits of underproof strength into the same volume, it is necessary to dilute overproof spirits and distil into two, three, or four times the original volume.

The strength of spirits can also be determined by boiling off the alcohol, etc. (Tabarie's method). For details and Blunt's improved formula for calculating results, see p. 105.

Obscuration. The amount by which the true alcoholic strength of brandy or rum differs from the apparent strength as indicated by a hydrometer or a density determination is termed the "obscuration."

In "The Sale of Food and Drugs Act Amendment Act, 1879," section 6, it is enacted that Brandy, Whisky, or Rum may be reduced to 25° u.p. and Gin to 35° u.p.

This, however, has been superseded, and at the present time (1920) no spirits are allowed to be sold at a higher strength than 30° u.p.

The following example will show how to calculate percentages of added water in diluted spirits.

Suppose 25° u.p. is allowed.

If a sample is N° u.p., 100 volumes will contain N volumes of water, and (100 − N) volumes of proof spirit.

Let x be the percentage of water by volume added to spirit of 25° u.p. to produce a sample N° u.p.

Then, equating amounts of water, we have

$$(100 - x)\frac{25}{100} + x = N,$$

$$25 - \frac{x}{4} + x = N,$$

$$\frac{3}{4}x = N - 25,$$

$$x = \frac{4}{3}(N - 25).$$

Hence, to get added water increase the excess of degrees u.p. above 25 by one-third.

Similarly, if 30° u.p. are allowed, the formula becomes

$$x_1 = \frac{10}{7}(N - 30),$$

and if 35° u.p. are allowed,

$$x_2 = \frac{20}{13}(N - 35) = 1·54(N - 35).$$

TABLE SHOWING THE AMOUNTS TO BE *subtracted* FROM THE VALUES GIVEN IN THE PHOSPHATE TABLE SO THAT THEY MAY BE IN ACCORDANCE WITH THE INTERNATIONAL ATOMIC WEIGHTS OF 1921.

$Mg_2P_2O_7$.	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	
10·0	0·03	0·02	0·02	
15·0	0·05	0·03	0·03	0·008
20·0	0·07	0·05	0·03	0·011
25·0	0·08	0·06	0·04	0·013
30·0	0·09	0·07	0·05	0·016
35·0	0·11	0·08	0·06	0·019
40·0	0·13	0·09	0·07	0·021
45·0	0·15	0·10	0·07	0·025
50·0	0·16	0·12	0·08	0·027
55·0	0·18	0·13	0·09	0·029
60·0	0·19	0·13	0·10	0·032
65·0	0·21	0·14	0·11	0·035
70·0	0·23	0·15	0·12	0·038

Ex. 2 grams of a sample of Superphosphate gave 0·3770 gram $Mg_2P_2O_7$.

From the table 37·70 = 52·61 $Ca_3P_2O_8$

Correction (mean of ·11 and ·13) ·12

2)52·52

26·26 % $Ca_3P_2O_8$

TABLE FOR PHOSPHATES.

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
0·1	0·14	0·09	0·06	0·028	4·1	5·73	3·66	2·62	1·145
·2	0·28	0·18	0·13	0·056	·2	5·87	3·75	2·69	1·173
·3	0·42	0·27	0·19	0·084	·3	6·00	3·84	2·75	1·201
·4	0·56	0·36	0·26	0·112	·4	6·14	3·93	2·82	1·229
·5	0·70	0·45	0·32	0·140	·5	6·28	4·01	2·88	1·257
·6	0·84	0·54	0·38	0·168	·6	6·42	4·10	2·94	1·285
·7	0·98	0·62	0·45	0·196	·7	6·56	4·19	3·01	1·313
·8	1·12	0·71	0·51	0·223	·8	6·70	4·28	3·07	1·341
·9	1·26	0·80	0·58	0·251	·9	6·84	4·37	3·14	1·369
1·0	1·40	0·89	0·64	0·279	5·0	6·98	4·46	3·20	1·396
·1	1·54	0·98	0·70	0·307	·1	7·12	4·55	3·26	1·424
·2	1·68	1·07	0·77	0·335	·2	7·26	4·64	3·33	1·452
·3	1·82	1·16	0·83	0·363	·3	7·40	4·73	3·39	1·480
·4	1·96	1·25	0·90	0·391	·4	7·54	4·82	3·45	1·508
·5	2·09	1·34	0·96	0·419	·5	7·68	4·91	3·52	1·536
·6	2·23	1·43	1·02	0·447	·6	7·82	5·00	3·58	1·564
·7	2·37	1·52	1·09	0·475	·7	7·96	5·08	3·65	1·592
·8	2·51	1·61	1·15	0·503	·8	8·10	5·17	3·71	1·620
·9	2·65	1·70	1·22	0·531	·9	8·24	5·26	3·77	1·648
2·0	2·79	1·78	1·28	0·559	6·0	8·38	5·35	3·84	1·676
·1	2·93	1·87	1·34	0·587	·1	8·52	5·44	3·90	1·704
·2	3·07	1·96	1·41	0·614	·2	8·66	5·53	3·97	1·732
·3	3·21	2·05	1·47	0·642	·3	8·80	5·62	4·03	1·760
·4	3·35	2·14	1·54	0·670	·4	8·94	5·71	4·09	1·787
·5	3·49	2·22	1·60	0·698	·5	9·08	5·80	4·16	1·815
·6	3·63	2·32	1·66	0·726	·6	9·22	5·89	4·22	1·843
·7	3·77	2·41	1·73	0·754	·7	9·36	5·98	4·29	1·871
·8	3·91	2·50	1·79	0·782	·8	9·50	6·07	4·35	1·899
·9	4·05	2·59	1·86	0·810	·9	9·64	6·15	4·41	1·927
3·0	4·19	2·68	1·92	0·838	7·0	9·77	6·24	4·48	1·955
·1	4·33	2·77	1·98	0·866	·1	9·91	6·33	4·54	1·983
·2	4·47	2·85	2·05	0·894	·2	10·05	6·42	4·61	2·011
·3	4·61	2·94	2·11	0·922	·3	10·19	6·51	4·67	2·039
·4	4·75	3·03	2·18	0·950	·4	10·33	6·60	4·73	2·067
·5	4·89	3·12	2·24	0·978	·5	10·47	6·69	4·80	2·095
·6	5·03	3·21	2·30	1·006	·6	10·61	6·78	4·86	2·123
·7	5·17	3·30	2·37	1·033	·7	10·75	6·87	4·93	2·151
·8	5·31	3·39	2·43	1·061	·8	10·89	6·96	4·99	2·178
·9	5·45	3·48	2·50	1·089	·9	11·03	7·05	5·05	2·206
4·0	5·59	3·57	2·56	1·117	8·0	11·17	7·14	5·12	2·234

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
8·1	11·31	7·22	5·18	2·262	12·7	17·73	11·33	8·12	3·547
·2	11·45	7·31	5·25	2·290	·8	17·87	11·42	8·19	3·575
·3	11·59	7·40	5·31	2·318	·9	18·01	11·51	8·25	3·603
·4	11·73	7·49	5·37	2·346	13·0	18·15	11·60	8·32	3·631
·5	11·87	7·58	5·44	2·374	·1	18·29	11·68	8·38	3·659
·6	12·01	7·67	5·50	2·402	·2	18·43	11·77	8·44	3·687
·7	12·15	7·76	5·57	2·430	·3	18·57	11·86	8·51	3·714
·8	12·29	7·85	5·63	2·458	·4	18·71	11·95	8·57	3·742
·9	12·43	7·94	5·69	2·486	·5	18·85	12·04	8·64	3·770
9·0	12·57	8·03	5·76	2·514	·6	18·99	12·13	8·70	3·798
·1	12·71	8·12	5·82	2·541	·7	19·13	12·22	8·76	3·826
·2	12·85	8·21	5·89	2·569	·8	19·27	12·31	8·83	3·854
·3	12·99	8·30	5·95	2·597	·9	19·41	12·40	8·89	3·882
·4	13·13	8·38	6·01	2·625	14·0	19·55	12·49	8·96	3·910
·5	13·27	8·47	6·08	2·653	·1	19·69	12·58	9·02	3·938
·6	13·41	8·56	6·14	2·681	·2	19·83	12·67	9·08	3·966
·7	13·55	8·65	6·21	2·709	·3	19·97	12·75	9·15	3·994
·8	13·69	8·74	6·27	2·737	·4	20·11	12·84	9·21	4·022
·9	13·83	8·83	6·33	2·765	·5	20·25	12·93	9·28	4·050
10·0	13·96	8·92	6·40	2·793	·6	20·39	13·02	9·34	4·078
·1	14·10	9·01	6·46	2·821	·7	20·53	13·11	9·40	4·105
·2	14·24	9·10	6·52	2·849	·8	20·67	13·20	9·47	4·133
·3	14·38	9·19	6·59	2·877	·9	20·81	13·29	9·53	4·161
·4	14·52	9·28	6·65	2·905	15·0	20·95	13·38	9·60	4·189
·5	14·66	9·37	6·72	2·932	·1	21·09	13·47	9·66	4·217
·6	14·80	9·45	6·78	2·960	·2	21·23	13·56	9·72	4·245
·7	14·94	9·54	6·84	2·988	·3	21·37	13·65	9·79	4·273
·8	15·08	9·63	6·91	3·016	·4	21·50	13·74	9·85	4·301
·9	15·22	9·72	6·97	3·044	·5	21·64	13·83	9·92	4·329
11·0	15·36	9·81	7·04	3·072	·6	21·78	13·91	9·98	4·357
·1	15·50	9·90	7·10	3·100	·7	21·92	14·00	10·04	4·385
·2	15·64	9·99	7·16	3·128	·8	22·06	14·09	10·11	4·413
·3	15·78	10·08	7·23	3·156	·9	22·20	14·18	10·17	4·441
·4	15·92	10·17	7·29	3·184	16·0	22·34	14·27	10·23	4·469
·5	16·06	10·26	7·36	3·212	·1	22·48	14·36	10·30	4·496
·6	16·20	10·35	7·42	3·240	·2	22·62	14·45	10·36	4·524
·7	16·34	10·44	7·48	3·268	·3	22·76	14·54	10·43	4·552
·8	16·48	10·53	7·55	3·296	·4	22·90	14·63	10·49	4·580
·9	16·62	10·61	7·61	3·324	·5	23·04	14·72	10·55	4·608
12·0	16·76	10·70	7·68	3·351	·6	23·18	14·81	10·62	4·636
·1	16·90	10·79	7·74	3·379	·7	23·32	14·90	10·68	4·664
·2	17·04	10·88	7·80	3·407	·8	23·46	14·98	10·75	4·692
·3	17·18	10·97	7·87	3·435	·9	23·60	15·07	10·81	4·720
·4	17·32	11·06	7·93	3·463	17·0	23·74	15·16	10·87	4·748
·5	17·46	11·15	8·00	3·491	·1	23·88	15·25	10·94	4·776
·6	17·60	11·24	8·06	3·519	·2	24·02	15·34	11·00	4·804

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
17·3	24·16	15·43	11·07	4·832	21·3	29·74	19·00	13·62	5·949
·4	24·30	15·52	11·13	4·860	·4	29·88	19·09	13·69	5·977
·5	24·44	15·61	11·19	4·887	·5	30·02	19·18	13·75	6·005
·6	24·58	15·70	11·26	4·915	·6	30·16	19·27	13·82	6·033
·7	24·72	15·79	11·32	4·943	·7	30·30	19·35	13·88	6·060
·8	24·86	15·88	11·39	4·971	·8	30·44	19·44	13·94	6·088
·9	25·00	15·97	11·45	4·999	·9	30·58	19·53	14·01	6·116
18·0	25·14	16·05	11·51	5·027	22·0	30·72	19·62	14·07	6·144
·1	25·27	16·14	11·58	5·055	·1	30·86	19·71	14·14	6·172
·2	25·41	16·23	11·64	5·083	·2	31·00	19·80	14·20	6·200
·3	25·55	16·32	11·71	5·111	·3	31·14	19·89	14·26	6·228
·4	25·69	16·41	11·77	5·139	·4	31·28	19·98	14·33	6·256
·5	25·83	16·50	11·83	5·167	·5	31·42	20·07	14·39	6·284
·6	25·97	16·59	11·90	5·195	·6	31·56	20·16	14·46	6·312
·7	26·11	16·68	11·96	5·223	·7	31·70	20·25	14·52	6·340
·8	26·25	16·77	12·03	5·250	·8	31·84	20·34	14·58	6·368
·9	26·39	16·86	12·09	5·278	·9	31·98	20·43	14·65	6·396
19·0	26·53	16·95	12·15	5·306	23·0	32·12	20·51	14·71	6·423
·1	26·67	17·04	12·22	5·334	·1	32·26	20·60	14·78	6·451
·2	26·81	17·12	12·28	5·362	·2	32·40	20·69	14·84	6·479
·3	26·95	17·21	12·35	5·390	·3	32·54	20·78	14·90	6·507
·4	27·09	17·30	12·41	5·418	·4	32·68	20·87	14·97	6·535
·5	27·23	17·39	12·47	5·446	·5	32·82	20·96	15·03	6·563
·6	27·37	17·48	12·54	5·474	·6	32·96	21·05	15·10	6·591
·7	27·51	17·57	12·60	5·502	·7	33·09	21·14	15·16	6·619
·8	27·65	17·66	12·67	5·530	·8	33·23	21·23	15·22	6·647
·9	27·79	17·75	12·73	5·558	·9	33·37	21·32	15·29	6·675
20·0	27·93	17·84	12·79	5·586	24·0	33·51	21·41	15·35	6·703
·1	28·07	17·93	12·86	5·614	·1	33·65	21·50	15·42	6·731
·2	28·21	18·02	12·92	5·642	·2	33·79	21·58	15·48	6·759
·3	28·35	18·11	12·99	5·669	·3	33·93	21·67	15·54	6·787
·4	28·49	18·20	13·05	5·697	·4	34·07	21·76	15·61	6·814
·5	28·63	18·28	13·11	5·725	·5	34·21	21·85	15·67	6·842
·6	28·77	18·37	13·18	5·753	·6	34·35	21·94	15·74	6·870
·7	28·91	18·46	13·24	5·781	·7	34·49	22·03	15·80	6·898
·8	29·05	18·55	13·31	5·809	·8	34·63	22·12	15·86	6·926
·9	29·19	18·64	13·37	5·837	·9	34·77	22·21	15·93	6·954
21·0	29·32	18·73	13·43	5·865	25·0	34·91	22·30	15·99	6·982
·1	29·46	18·82	13·50	5·893	·1	35·05	22·39	16·06	7·010
·2	29·60	18·91	13·56	5·921	·2	35·19	22·48	16·12	7·038

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	·04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	·04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
25·3	35·33	22·57	16·18	7·066	29·9	41·75	26·67	19·13	8·351
·4	35·47	22·66	16·25	7·094	30·0	41·89	26·76	19·19	8·378
·5	35·61	22·74	16·31	7·122	·1	42·03	26·85	19·25	8·406
·6	35·75	22·83	16·38	7·150	·2	42·17	26·94	19·32	8·434
·7	35·89	22·92	16·44	7·178	·3	42·31	27·03	19·38	8·462
·8	36·03	23·01	16·50	7·206	·4	42·45	27·11	19·45	8·490
·9	36·17	23·10	16·57	7·234	·5	42·59	27·20	19·51	8·518
26·0	36·31	23·19	16·63	7·261	·6	42·73	27·29	19·57	8·546
·1	36·45	23·28	16·70	7·289	·7	42·87	27·38	19·64	8·574
·2	36·59	23·37	16·76	7·317	·8	43·01	27·47	19·70	8·602
·3	36·73	23·46	16·82	7·345	·9	43·15	27·56	19·77	8·630
·4	36·87	23·55	16·89	7·373	31·0	43·29	27·65	19·83	8·658
·5	37·00	23·64	16·95	7·401	·1	43·43	27·74	19·89	8·686
·6	37·14	23·72	17·02	7·429	·2	43·57	27·83	19·96	8·714
·7	37·28	23·81	17·08	7·457	·3	43·71	27·92	20·02	8·742
·8	37·42	23·90	17·14	7·485	·4	43·85	28·01	20·09	8·769
·9	37·56	23·99	17·21	7·513	·5	43·99	28·10	20·15	8·797
27·0	37·70	24·08	17·27	7·541	·6	44·13	28·18	20·21	8·825
·1	37·84	24·17	17·33	7·569	·7	44·27	28·27	20·28	8·853
·2	37·98	24·26	17·40	7·597	·8	44·41	28·36	20·34	8·881
·3	38·12	24·35	17·46	7·624	·9	44·55	28·45	20·41	8·909
·4	38·26	24·44	17·53	7·652	32·0	44·69	28·54	20·47	8·937
·5	38·40	24·53	17·59	7·680	·1	44·82	28·63	20·53	8·965
·6	38·54	24·62	17·65	7·708	·2	44·96	28·72	20·60	8·993
·7	38·68	24·71	17·72	7·736	·3	45·10	28·81	20·66	9·021
·8	38·82	24·80	17·78	7·764	·4	45·24	28·90	20·72	9·049
·9	38·96	24·88	17·85	7·792	·5	45·38	28·99	20·79	9·077
28·0	39·10	24·97	17·91	7·820	·6	45·52	29·08	20·85	9·105
·1	39·24	25·06	17·97	7·848	·7	45·66	29·17	20·92	9·133
·2	39·38	25·15	18·04	7·876	·8	45·80	29·26	20·98	9·160
·3	39·52	25·24	18·10	7·904	·9	45·94	29·34	21·04	9·188
·4	39·66	25·33	18·17	7·932	33·0	46·08	29·43	21·11	9·216
·5	39·80	25·42	18·23	7·959	·1	46·22	29·52	21·17	9·244
·6	39·94	25·51	18·29	7·987	·2	46·36	29·61	21·24	9·272
·7	40·08	25·60	18·36	8·015	·3	46·50	29·70	21·30	9·300
·8	40·22	25·69	18·42	8·043	·4	46·64	29·79	21·36	9·328
·9	40·36	25·78	18·49	8·071	·5	46·78	29·88	21·43	9·356
29·0	40·50	25·87	18·55	8·099	·6	46·92	29·97	21·49	9·384
·1	40·64	25·95	18·61	8·127	·7	47·06	30·06	21·56	9·412
·2	40·78	26·04	18·68	8·155	·8	47·20	30·15	21·62	9·440
·3	40·92	26·13	18·74	8·183	·9	47·34	30·24	21·68	9·468
·4	41·06	26·22	18·81	8·211	34·0	47·48	30·33	21·75	9·496
·5	41·19	26·31	18·87	8·239	·1	47·62	30·41	21·81	9·523
·6	41·33	26·40	18·93	8·267	·2	47·76	30·50	21·88	9·551
·7	41·47	26·49	19·00	8·295	·3	47·90	30·59	21·94	9·579
·8	41·61	26·58	19·06	8·323	·4	48·04	30·68	22·00	9·607

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
34·5	48·18	30·77	22·07	9·635	38·5	53·76	34·31	24·63	10·752
·6	48·32	30·86	22·13	9·663	·6	53·90	34·40	24·69	10·780
·7	48·46	30·95	22·20	9·691	·7	54·04	34·52	24·75	10·808
·8	48·60	31·04	22·26	9·719	·8	54·18	34·61	24·82	10·836
·9	48·74	31·13	22·32	9·747	·9	54·32	34·70	24·88	10·864
35·0	48·87	31·22	22·39	9·775	39·0	54·46	34·78	24·95	10·892
·1	49·01	31·31	22·45	9·803	·1	54·60	34·87	25·01	10·920
·2	49·15	31·40	22·52	9·831	·2	54·74	34·96	25·07	10·948
·3	49·29	31·49	22·58	9·859	·3	54·88	35·05	25·14	10·976
·4	49·43	31·57	22·64	9·887	·4	55·02	35·14	25·20	11·004
·5	49·57	31·66	22·71	9·914	·5	55·16	35·23	25·27	11·032
·6	49·71	31·75	22·77	9·942	·6	55·30	35·32	25·33	11·060
·7	49·85	31·84	22·84	9·970	·7	55·44	35·41	25·39	11·087
·8	49·99	31·93	22·90	9·998	·8	55·58	35·50	25·46	11·115
·9	50·13	32·02	22·96	10·026	·9	55·72	35·59	25·52	11·143
36·0	50·27	32·11	23·03	10·054	40·0	55·86	35·68	25·59	11·171
·1	50·41	32·20	23·09	10·082	·1	56·00	35·77	25·65	11·199
·2	50·55	32·29	23·16	10·110	·2	56·14	35·85	25·71	11·227
·3	50·69	32·38	23·22	10·138	·3	56·28	35·94	25·78	11·255
·4	50·83	32·47	23·28	10·166	·4	56·42	36·03	25·84	11·283
·5	50·97	32·55	23·35	10·194	·5	56·55	36·12	25·91	11·311
·6	51·11	32·64	23·41	10·222	·6	56·69	36·21	25·97	11·339
·7	51·25	32·73	23·48	10·250	·7	56·83	36·30	26·03	11·367
·8	51·39	32·82	23·54	10·278	·8	56·97	36·39	26·10	11·395
·9	51·53	32·91	23·60	10·306	·9	57·11	36·48	26·16	11·423
37·0	51·67	33·00	23·67	10·333	41·0	57·25	36·57	26·23	11·451
·1	51·81	33·09	23·73	10·361	·1	57·39	36·66	26·29	11·478
·2	51·95	33·18	23·80	10·389	·2	57·53	36·75	26·35	11·506
·3	52·09	33·27	23·86	10·417	·3	57·67	36·84	26·42	11·534
·4	52·23	33·36	23·92	10·445	·4	57·81	36·93	26·48	11·562
·5	52·37	33·45	23·99	10·473	·5	57·95	37·01	26·55	11·590
·6	52·51	33·54	24·05	10·501	·6	58·09	37·10	26·61	11·618
·7	52·64	33·62	24·12	10·529	·7	58·23	37·19	26·67	11·646
·8	52·78	33·71	24·18	10·557	·8	58·37	37·28	26·74	11·674
·9	52·92	33·80	24·24	10·585	·9	58·51	37·37	26·80	11·702
38·0	53·06	33·89	24·31	10·613	42·0	58·65	37·46	26·87	11·730
·1	53·20	33·98	24·37	10·641	·1	58·79	37·55	26·93	11·758
·2	53·34	34·07	24·43	10·669	·2	58·93	37·64	26·99	11·786
·3	53·48	34·16	24·50	10·696	·3	59·07	37·73	27·06	11·814
·4	53·62	34·25	24·56	10·724	·4	59·21	37·82	27·12	11·842

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	·04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	·04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
42·5	59·35	37·91	27·19	11·869	47·1	65·77	42·01	30·13	13·154
·6	59·49	38·00	27·25	11·897	·2	65·91	42·10	30·19	13·182
·7	59·63	38·08	27·31	11·925	·3	66·05	42·19	30·26	13·210
·8	59·77	38·17	27·38	11·953	·4	66·19	42·28	30·32	13·238
·9	59·91	38·26	27·44	11·981	·5	66·33	42·37	30·38	13·266
43·0	60·05	38·35	27·51	12·009	·6	66·47	42·45	30·45	13·294
·1	60·19	38·44	27·57	12·037	·7	66·61	42·54	30·51	13·322
·2	60·32	38·53	27·63	12·065	·8	66·75	42·63	30·58	13·350
·3	60·46	38·62	27·70	12·093	·9	66·89	42·72	30·64	13·378
·4	60·60	38·71	27·76	12·121	48·0	67·03	42·81	30·70	13·405
·5	60·74	38·80	27·82	12·149	·1	67·17	42·90	30·77	13·433
·6	60·88	38·89	27·89	12·177	·2	67·31	42·99	30·83	13·461
·7	61·02	38·98	27·95	12·205	·3	67·45	43·08	30·90	13·489
·8	61·16	39·07	28·02	12·232	·4	67·59	43·17	30·96	13·517
·9	61·30	39·16	28·08	12·260	·5	67·73	43·26	31·02	13·545
44·0	61·44	39·24	28·14	12·288	·6	67·87	43·35	31·09	13·573
·1	61·58	39·33	28·21	12·316	·7	68·00	43·44	31·15	13·601
·2	61·72	39·42	28·27	12·344	·8	68·14	43·53	31·22	13·629
·3	61·86	39·51	28·34	12·372	·9	68·28	43·61	31·28	13·657
·4	62·00	39·60	28·40	12·400	49·0	68·42	43·70	31·34	13·685
·5	62·14	39·69	28·46	12·428	·1	68·56	43·79	31·41	13·713
·6	62·28	39·78	28·53	12·456	·2	68·70	43·88	31·47	13·741
·7	62·42	39·87	28·59	12·484	·3	68·84	43·97	31·53	13·769
·8	62·56	39·96	28·66	12·512	·4	68·98	44·06	31·60	13·796
·9	62·70	40·05	28·72	12·540	·5	69·12	44·15	31·66	13·824
45·0	62·84	40·14	28·78	12·568	·6	69·26	44·24	31·73	13·852
·1	62·98	40·23	28·85	12·596	·7	69·40	44·33	31·79	13·880
·2	63·12	40·31	28·91	12·624	·8	69·54	44·42	31·85	13·908
·3	63·26	40·40	28·98	12·651	·9	69·68	44·51	31·92	13·936
·4	63·40	40·49	29·04	12·679	50·0	69·82	44·60	31·98	13·964
·5	63·54	40·58	29·10	12·707	·1	69·96	44·68	32·05	13·992
·6	63·68	40·67	29·17	12·735	·2	70·10	44·77	32·11	14·020
·7	63·82	40·76	29·23	12·763	·3	70·24	44·86	32·17	14·048
·8	63·96	40·85	29·30	12·791	·4	70·38	44·95	32·24	14·076
·9	64·10	40·94	29·36	12·819	·5	70·52	45·04	32·30	14·104
46·0	64·23	41·03	29·42	12·847	·6	70·66	45·13	32·37	14·132
·1	64·37	41·12	29·49	12·875	·7	70·80	45·22	32·43	14·160
·2	64·51	41·21	29·55	12·903	·8	70·94	45·31	32·49	14·187
·3	64·65	41·30	29·62	12·931	·9	71·08	45·40	32·56	14·215
·4	64·79	41·38	29·68	12·959	51·0	71·22	45·49	32·62	14·243
·5	64·93	41·47	29·74	12·987	·1	71·36	45·58	32·69	14·271
·6	65·07	41·56	29·81	13·015	·2	71·50	45·67	32·75	14·299
·7	65·21	41·65	29·87	13·042	·3	71·64	45·76	32·81	14·327
·8	65·35	41·74	29·94	13·070	·4	71·78	45·84	32·88	14·355
·9	65·49	41·83	30·00	13·098	·5	71·91	45·93	32·94	14·383
47·0	65·63	41·92	30·06	13·126	·6	72·05	46·02	33·01	14·411

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
51·7	72·19	46·11	33·07	14·439	55·7	77·78	49·68	35·63	15·556
·8	72·33	46·20	33·13	14·467	·8	77·92	49·77	35·69	15·584
·9	72·47	46·29	33·26	14·495	·9	78·06	49·86	35·76	15·612
52·0	72·61	46·38	33·26	14·523	56·0	78·20	49·95	35·82	15·640
·1	72·75	46·47	33·33	14·551	·1	78·34	50·04	35·88	15·668
·2	72·89	46·56	33·39	14·579	·2	78·48	50·12	35·95	15·696
·3	73·03	46·65	33·45	14·606	·3	78·62	50·21	36·01	15·724
·4	73·17	46·74	33·52	14·634	·4	78·76	50·30	36·08	15·751
·5	73·31	46·83	33·58	14·662	·5	78·90	50·39	36·14	15·779
·6	73·45	46·91	33·65	14·690	·6	79·04	50·48	36·20	15·807
·7	73·59	47·00	33·71	14·718	·7	79·18	50·57	36·27	15·835
·8	73·73	47·09	33·77	14·746	·8	79·32	50·66	36·33	15·863
·9	73·87	47·18	33·84	14·774	·9	79·46	50·75	36·40	15·891
53·0	74·01	47·27	33·90	14·802	57·0	79·60	50·84	36·46	15·919
·1	74·15	47·36	33·97	14·830	·1	79·74	50·93	36·52	15·947
·2	74·29	47·45	34·03	14·858	·2	79·87	51·02	36·59	15·975
·3	74·43	47·54	34·09	14·886	·3	80·01	51·11	36·65	16·003
·4	74·57	47·63	34·16	14·914	·4	80·15	51·20	36·72	16·031
·5	74·71	47·72	34·22	14·941	·5	80·29	51·28	36·78	16·059
·6	74·85	47·81	34·29	14·969	·6	80·43	51·37	36·84	16·087
·7	74·99	47·90	34·35	14·997	·7	80·57	51·46	36·91	16·115
·8	75·13	47·99	34·41	15·025	·8	80·71	51·55	36·97	16·142
·9	75·27	48·07	34·48	15·053	·9	80·85	51·64	37·04	16·170
54·0	75·41	48·16	34·54	15·081	58·0	80·99	51·73	37·10	16·198
·1	75·55	48·25	34·61	15·109	·1	81·13	51·82	37·16	16·226
·2	75·69	48·34	34·67	15·137	·2	81·27	51·91	37·23	16·254
·3	75·83	48·43	34·73	15·165	·3	81·41	52·00	37·29	16·282
·4	75·97	48·52	34·80	15·193	·4	81·55	52·09	37·36	16·310
·5	76·10	48·61	34·86	15·221	·5	81·69	52·18	37·42	16·338
·6	76·24	48·70	34·93	15·249	·6	81·83	52·27	37·48	16·366
·7	76·38	48·79	34·99	15·277	·7	81·97	52·35	37·55	16·394
·8	76·52	48·88	35·05	15·305	·8	82·11	52·44	37·61	16·422
·9	76·66	48·97	35·12	15·333	·9	82·25	52·53	37·68	16·450
55·0	76·80	49·06	35·18	15·360	59·0	82·39	52·62	37·74	16·478
·1	76·94	49·14	35·24	15·388	·1	82·53	52·71	37·80	16·505
·2	77·08	49·23	35·31	15·416	·2	82·67	52·80	37·87	16·533
·3	77·22	49·32	35·37	15·444	·3	82·81	52·89	37·93	16·561
·4	77·36	49·41	35·44	15·472	·4	82·95	52·98	38·00	16·589
·5	77·50	49·50	35·50	15·500	·5	83·09	53·07	38·06	16·617
·6	77·64	49·59	35·56	15·528	·6	83·23	53·16	38·12	16·645

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	·04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	·04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
59·7	83·37	53·25	38·19	16·673	61·0	85·18	54·41	39·02	17·036
·8	83·51	53·34	38·25	16·701	62	86·58	55·30	39·66	17·315
·9	83·65	53·43	38·32	16·729	63	87·97	56·19	40·30	17·595
60·0	83·78	53·51	38·38	16·757	64	89·37	57·08	40·94	17·874
·1	83·92	53·60	38·44	16·785	65	90·77	57·97	41·58	18·153
·2	84·06	53·69	38·51	16·813	66	92·16	58·87	42·22	18·433
·3	84·20	53·78	38·57	16·841	67	93·56	59·76	42·86	18·712
·4	84·34	53·87	38·63	16·869	68	94·96	60·65	43·50	18·991
·5	84·48	53·96	38·70	16·897	69	96·35	61·54	44·14	19·270
·6	84·62	54·05	38·76	16·924	70	97·75	62·43	44·78	19·550
·7	84·76	54·14	38·83	16·952	71	99·14	63·32	45·41	19·829
·8	84·90	54·23	38·89	16·980		100·00	63·87	45·81	20·000
·9	85·04	54·32	38·95	17·008					

TABLE FOR THE CONVERSION OF NITROGEN INTO AMMONIA AND ALBUMINOIDS (= N × 6·25).

N.	NH_3	Albuminoids ($N \times 6·25$)	N	NH_3	Albuminoids ($N \times 6·25$)	N.	NH_3	Albuminoids ($N \times 6·25$)
0·1	0·12	0·63	1·9	2·31	11·88	3·7	4·49	23·13
·2	·24	1·25	2·0	2·43	12·50	·8	4·61	23·75
·3	·36	1·88	·1	2·55	13·13	·9	4·73	24·38
·4	·49	2·50	·2	2·67	13·75	4·0	4·86	25·00
·5	·61	3·13	·3	2·79	14·38	·1	4·98	25·63
·6	·73	3·75	·4	2·91	15·00	·2	5·10	26·25
·7	·85	4·38	·5	3·04	15·63	·3	5·22	26·88
·8	·97	5·00	·6	3·16	16·25	·4	5·34	27·50
·9	1·09	5·63	·7	3·28	16·88	·5	5·46	28·13
1·0	1·21	6·25	·8	3·40	17·50	·6	5·58	28·75
·1	1·34	6·88	·9	3·52	18·13	·7	5·71	29·38
·2	1·46	7·50	3·0	3·64	18·75	·8	5·83	30·00
·3	1·58	8·13	·1	3·76	19·38	·9	5·95	30·63
·4	1·70	8·75	·2	3·88	20·00	5·0	6·08	31·25
·5	1·82	9·38	·3	4·01	20·63	·1	6·20	31·88
·6	1·94	10·00	·4	4·13	21·25	·2	6·32	32·50
·7	2·06	10·63	·5	4·25	21·88	·3	6·44	33·13
·8	2·19	11·25	·6	4·37	22·50	·4	6·57	33·75

N	·01	·02	·03	04	·05	·06	·07	·08	·09
NH_3	·01	·02	·04	·05	·06	·07	·09	·10	·11
Albuminoids	·06	·13	·19	·25	·31	·38	·44	·50	·56

TABLE FOR THE CONVERSION OF NITROGEN INTO AMMONIA AND ALBUMINOIDS—*continued.*

N.	NH_3.	Albuminoids (N × 6·25).	N.	NH_3.	Albuminoids (N × 6·25).	N.	NH_3.	Albuminoids (N × 6·25).
5·5	6·69	34·38	9·1	11·06	56·88	12·6	15·32	78·75
·6	6·81	35·00	·2	11·19	57·50	·7	15·44	79·38
·7	6·93	35·63	·3	11·31	58·13	·8	15·56	80·00
·8	7·05	36·25	·4	11·43	58·75	·9	15·68	80·63
·9	7·17	36·88	·5	11·55	59·38	13·0	15·81	81·25
6·0	7·30	37·50	·6	11·67	60·00	·1	15·93	81·88
·1	7·42	38·13	·7	11·79	60·63	·2	16·05	82·50
·2	7·54	38·75	·8	11·92	61·25	·3	16·17	83·13
·3	7·66	39·38	·9	12·04	61·88	·4	16·29	83·75
·4	7·78	40·00	10·0	12·16	62·50	·5	16·41	84·38
·5	7·90	40·63	·1	12·28	63·13	·6	16·54	85·00
·6	8·02	41·25	·2	12·40	63·75	·7	16·66	85·63
·7	8·15	41·88	·3	12·52	64·38	·8	16·78	86·25
·8	8·27	42·50	·4	12·64	65·00	·9	16·90	86·88
·9	8·39	43·13	·5	12·77	65·63	14·0	17·02	87·50
7·0	8·51	43·75	·6	12·89	66·25	·1	17·14	88·13
·1	8·63	44·38	·7	13·01	66·88	·2	17·27	88·75
·2	8·75	45·00	·8	13·13	67·50	·3	17·39	89·38
·3	8·88	45·63	·9	13·25	68·13	·4	17·51	90·00
·4	9·00	46·25	11·0	13·37	68·75	·5	17·63	90·63
·5	9·12	46·88	·1	13·50	69·38	·6	17·75	91·25
·6	9·24	47·50	·2	13·62	70·00	·7	17·87	91·88
·7	9·36	48·13	·3	13·74	70·63	·8	17·99	92·50
·8	9·48	48·75	·4	13·86	71·25	·9	18·12	93·13
·9	9·61	49·38	·5	13·98	71·88	15·0	18·24	93·75
8·0	9·73	50·00	·6	14·10	72·50	·1	18·36	94·38
·1	9·85	50·63	·7	14·23	73·13	·2	18·48	95·00
·2	9·97	51·25	·8	14·35	73·75	·3	18·60	95·63
·3	10·09	51·88	·9	14·47	74·38	·4	18·72	96·25
·4	10·21	52·50	12·0	14·59	75·00	·5	18·85	96·88
·5	10·33	53·13	·1	14·71	75·63	·6	18·97	97·50
·6	10·46	53·75	·2	14·83	76·25	·7	19·09	98·13
·7	10·58	54·38	·3	14·95	76·88	·8	19·21	98·75
·8	10·70	55·00	·4	15·08	77·50	·9	19·33	99·38
·9	10·82	55·63	·5	15·20	78·13	16·0	19·45	100·00
9·0	10·94	56·25						

N	·01	·02	·03	·04	·05	·06	·07	·08	·09
NH_3	·01	·02	·04	·05	·06	·07	·09	·10	·11
Albuminoids	·06	·13	·19	·25	·31	·38	·44	·50	·56

TABLE FOR KJELDAHL PROCESS: 1 GRAM OF SUBSTANCE BEING USED

1 c.c. N/5 acid = 0·002802 gram N (log $\bar{3}$·44747)
,, = 0·003407 gram NH_3 (log $\bar{3}$·53237).

c.c. N/5 acid used	% N.	% NH_3	c.c. N/5 acid used	% N.	% NH_3	c.c. N/5 acid used	% N.	% NH_3
1·0	0·28	0·34	22·5	6·30	7·67	44·0	12·33	14·99
1·5	0·42	0·51	23·0	6·44	7·84	44·5	12·47	15·16
2·0	0·56	0·68	23·5	6·58	8·01	45·0	12·61	15·33
2·5	0·70	0·85	24·0	6·72	8·18	45·5	12·75	15·50
3·0	0·84	1·02	24·5	6·86	8·35	46·0	12·89	15·67
3·5	0·98	1·19	25·0	7·01	8·52	46·5	13·03	15·84
4·0	1·12	1·36	25·5	7·15	8·69	47·0	13·17	16·01
4·5	1·26	1·53	26·0	7·29	8·86	47·5	13·31	16·18
5·0	1·40	1·70	26·5	7·43	9·03	48·0	13·45	16·35
5·5	1·54	1·87	27·0	7·57	9·20	48·5	13·59	16·52
6·0	1·68	2·04	27·5	7·71	9·37	49·0	13·73	16·69
6·5	1·82	2·21	28·0	7·85	9·54	49·5	13·87	16·86
7·0	1·96	2·38	28·5	7·99	9·71	50·0	14·01	17·04
7·5	2·10	2·56	29·0	8·13	9·88	50·5	14·15	17·21
8·0	2·24	2·73	29·5	8·27	10·05	51·0	14·29	17·38
8·5	2·38	2·90	30·0	8·41	10·22	51·5	14·43	17·55
9·0	2·52	3·07	30·5	8·55	10·39	52·0	14·57	17·72
9·5	2·66	3·24	31·0	8·69	10·56	52·5	14·71	17·89
10·0	2·80	3·41	31·5	8·83	10·73	53·0	14·85	18·06
10·5	2·94	3·58	32·0	8·97	10·90	53·5	14·99	18·23
11·0	3·08	3·75	32·5	9·11	11·07	54·0	15·13	18·40
11·5	3·22	3·92	33·0	9·25	11·24	54·5	15·27	18·57
12·0	3·36	4·09	33·5	9·39	11·41	55·0	15·41	18·74
12·5	3·50	4·26	34·0	9·53	11·58	55·5	15·55	18·91
13·0	3·64	4·43	34·5	9·67	11·75	56·0	15·69	19·08
13·5	3·78	4·60	35·0	9·81	11·92	56·5	15·83	19·25
14·0	3·92	4·77	35·5	9·95	12·09	57·0	15·97	19·42
14·5	4·06	4·94	36·0	10·09	12·27	57·5	16·11	19·59
15·0	4·20	5·11	36·5	10·23	12·44	58·0	16·25	19·76
15·5	4·34	5·28	37·0	10·37	12·61	58·5	16·39	19·93
16·0	4·48	5·45	37·5	10·51	12·78	59·0	16·53	20·10
16·5	4·62	5·62	38·0	10·65	12·95	59·5	16·67	20·27
17·0	4·76	5·79	38·5	10·79	13·12	60·0	16·81	20·44
17·5	4·90	5·96	39·0	10·93	13·29	60·5	16·95	20·61
18·0	5·04	6·13	39·5	11·07	13·46	61·0	17·09	20·78
18·5	5·18	6·30	40·0	11·21	13·63	61·5	17·23	20·95
19·0	5·32	6·47	40·5	11·35	13·80	62·0	17·37	21·12
19·5	5·46	6·64	41·0	11·49	13·97			
20·0	5·60	6·81	41·5	11·63	14·14	0·1	0·03	0·03
20·5	5·74	6·98	42·0	11·77	14·31	0·2	0·06	0·07
21·0	5·88	7·15	42·5	11·91	14·48	0·3	0·08	0·10
21·5	6·02	7·33	43·0	12·05	14·65	0·4	0·11	0·14
22·0	6·16	7·50	43·5	12·19	14·82			

FACTORS FOR CALCULATING VARIOUS NITROGENOUS SUBSTANCES.

	Multiply Nitrogen by	Logarithm.	Authority.
Albuminoids	6·25	0·79588	...
Albumin	6·39	0·80550	Richmond
Casein	6·39	,,	,,
Proteins of cheese	6·39	,,	,,
,, ,, milk	6·39	,,	,,
,, ,, dried milk	6·38	0·80482	,,
Gelatin	5·5	0·74036	Allen and Searle: Mitchell
Proteins in meat-extract	6·33	0·80140	Allen and Searle
Hide substance (from nitrogen in leather)	5·62	0·74958	J. G. Parker

*The comparative values of feeding stuffs** are frequently expressed in terms of "food units," which are calculated as follows:

Multiply the sum of the percentages of oil and albuminoids by 2½ and add the percentage of "digestible carbohydrates." The result gives the percentage of food units.

Ex. Two linseed cakes contained

	A	B
Oil	14·36	10·06
Albuminoids	27·42	28·50
Digestible carbohydrates	32·59	34·13

Hence we have

A 14·36
27·42

41·78 × 2½† = 104·45 + 32·59 = Food Units 137

B 10·06
28·50

38·56 × 2½ = 96·40 + 34·13 = 130·5.

The relative values of A and B are thus

137 : 130·5, or 1·05 : 1.

It must be specially noticed that "food units" express the *total intrinsic value* of a feeding stuff—both as food, and as manure after it has passed through the animal.

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* Dyer, *Fertilizers and Feeding Stuffs*, p. 81.

† Best done by using the equivalent fraction $\frac{10}{4}$, thus $\frac{417·8}{4}$ = 104·45.

OILS, FATS, AND WAXES.

Oils are neutral bodies of more or less viscous consistence, liquid at the ordinary temperature, combustible, lighter than water and insoluble in it, sometimes soluble in alcohol, and always soluble in ether. Oils are classified as follows:—(i) *fatty* or *fixed* oils; (ii) *essential* or *volatile* oils; and (iii) *mineral* oils. The *fatty* or *fixed* oils are simply liquid fats, and, in contradistinction to the members of the second class, decompose when heated. *Essential* oils have strong and characteristic odours, and are vapourizable without decomposition, usually with little or no residue. Many essential oils consist of hydrocarbons or other fluid bodies mixed with solid oxidized compounds. On cooling such, or by evaporation, the latter often crystallize out, the solid thus separating being termed the *stearoptene*, whilst the liquid is called the *elaeoptene*. *Mineral* oils form a class somewhat by themselves, and include petroleum and oils distilled from peat, shale, etc.: they consist of mixtures of hydrocarbons.

Fats are the (neutral) triglycerides of the higher fatty acids. A great many fats may be considered as mixtures of the triglycerides of several fatty acids, as of tripalmitin, tristearin and triolein; but mixed esters of glycerol may also exist in fats, *e.g.*, oleo-palmito-butyrate in butter-fat.

Waxes are esters formed by the union of mono- or di-hydric alcohols with the higher fatty acids. The waxes, therefore, do not contain glycerol, and consequently, on being heated, do not emit the odour of acrolein, neither do they, on keeping, become rancid, owing to the stability of the esters of which they consist. Waxes are derived from both the animal and the vegetable kingdoms, beeswax being typical of the former, and carnauba wax of the latter.

Japan wax consists chiefly of glycerides, and hence is classed among "fats": whilst sperm oil contains only a small amount of glycerides, but a large percentage of unsaponifiable matter, and is classed among "waxes."

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(1) The *acid value* is the measure of the amount of free fatty acids in a fat or wax. It gives the number of milligrams of potassium hydroxide required to neutralize the free fatty acids in one gram of a fat or wax.

(2) The *saponification value*, or *Koltstorfer value*, is the number of milligrams of potassium hydroxide required to saponify completely one gram of a fat or wax (or gives grams of KHO required for 1000 grams of a fat or wax).

(3) The *ester value* gives the number of milligrams of potassium hydroxide required for the saponification of the neutral esters in one gram of a fat or wax.

If a fat contains no free fatty acids, (3) is identical with (2); but in the more usual case, in which small quantities of free fatty acids are present, (3) is obtained by subtracting (1) from (2).

(4) The *iodine value* is the percentage of iodine chloride (ICl) expressed in terms of iodine which is absorbed by an oil, fat, or wax.

(5) The *Hehner value* is the percentage of insoluble fatty acids + unsaponifiable matter in a fat or wax. For most fats it ranges from 95·5 to 96 per cent.

(6) The *Reichert Meissl value* is the number of c.c. of decinormal alkali required to neutralize the distillate of volatile acids obtained from 5 grams of a fat or wax by the Reichert distillation process.

(7) The *acetyl value* is the number of milligrams of potassium hydroxide required to neutralize the acetic acid obtained when 1 gram of an acetylated oil, fat, or wax is saponified.

Titer Test. This is the solidifying point in degrees Centigrade of the mixed fatty acids from an oil or fat.

Acid value × 0·502 = free fatty acids (expressed as oleic).

TABLES OF CONSTANTS OF OILS, FATS, AND WAXES.

I.—VEGETABLE OILS.

Name of Oil.	Sp. gr. at 15·5/15·5° C.	Solidifying Point (° C.).	Hehner's Value.*	Saponification Value.	Iodine Value.	Oleo-refractometer (Jean) at 22° C.	Butyro-refractometer (Zeiss).
Almond (N-D)	0·914–[illegible]	−10 to −20	96	19[illegible]	[illegible]	[illegible]	[illegible]
Apricot kernel (N-D)	0·917–[illegible]	−20		[illegible]	100–[illegible]		[illegible]
Arachis† (Earth-nut) (N-D)	0·911–[illegible]	[illegible]	95·[illegible]	[illegible]	83–[illegible]		[illegible]
Castor (S-D)	[illegible]	−10 to −12		[illegible]	[illegible]	[illegible]	[illegible]
Cotton-seed (S-D)	0·922–[illegible]	3–4	95·[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Croton (S-D)	0·9375–[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hemp-seed (D)	0·925–[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Linseed (D)	0·9315–[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maize (S-D)	0·9213–[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Black mustard (S-D)	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
White mustard (S-D)	0·914–[illegible]	[illegible]		[illegible]	[illegible]		[illegible]
Niger seed (D)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
Olive (N-D)	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Peach kernel (N-D)	0·918–[illegible]	below −20		18[illegible]	[illegible]	[illegible]	[illegible]
Poppy seed (D)	0·924–[illegible]	−15 to −20	95·5	19[illegible]	[illegible]	[illegible]	[illegible]
Pumpkin seed (S-D)	[illegible]	−15	96	19[illegible]	[illegible]	[illegible]	[illegible]
Rape (Colza) (S-D)	0·914–[illegible]	−10	[illegible]	[illegible]	[illegible]		[illegible]
Sesame (S-D)	0·921–[illegible]	−4 to −[illegible]	[illegible]	[illegible]	[illegible]	[illegible] to −20	[illegible]
Sunflower (D)	[illegible]	below −17	[illegible]	[illegible]	[illegible]	[illegible] to −17	[illegible]
Walnut (Nut) (D)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
Wheat (S-D)	[illegible]	semi-solid at [illegible]		[illegible]	115	[illegible]	[illegible]

D = drying. S-D = semi-drying. N-D = non-drying.

* The values recorded in this column include the unsaponifiable matter present. Hence here, as usually, Hehner value = insoluble fatty acids + unsaponifiable matter.

† Or Pea-nut oil.

Note.—In Zeiss's Butyro-refractometer a rise of temperature of 1° C. causes a lowering of [illegible] scale-division *approximately*.

TABLES OF CONSTANTS OF OILS, FATS, AND WAXES.

II.—ANIMAL OILS.

Name of Oil.	Sp. gr. @ 15·5°/15·5° C.	Solidifying Point (°C.).	Hehner Value.	Saponification Value.	Iodine Value.	Oleo-refractometer (Jean), @ 22° C.	Butyro-refractometer (Zeiss)
Cod liver	0·922-·930	0 to − 10	95·5	179-191	154-170	+ 40 to + 48	74-76 @ 30° C.
Lard oil	0·913-·919	− 4 to + 10	97	193-198	67-82	0 to − 1	58·5 @ 30° C.
Neat's foot	*0·914-·917	− 3 to − 4	94·5-95·9	194-199	66-73	− 1 to − 4	58 @ 30° C.
Seal	0·924-·929	− 2 to − 3	93-96	189-196	130-152	− 2 to + 36	64-65 @ 40° C.
Shark liver	0·916-·919	..	87-97	157-164	115-139	+ 22 to + 35	..
Sheep's foot	0·9175	0 to 1·5	.	194·75	74-74·4	0	..

III.—ANIMAL FATS.

Name of Fat.	Sp. gr. @ 99°/15·5° C.	Solidifying Point (°C.).	Hehner Value	Saponification Value	Iodine Value	Oleo-refractometer (Jean).	Butyro-refractometer (Zeiss).
Lard	†0·859-·861	27 − 30	93-95	195-203	58-63	− [illegible] to − [illegible] @ 45° C.	55·5-57 @ 30° C.
Beef Tallow	0·860-·861	38 − 46	95-96	194-200	40-47	− 15 to − 18 @ 45° C.	49 @ 40° C.
Mutton Tallow	0·858-·860	40 − 43	95-96	192-195	35-43	.	..

* ·9[illegible] @ 100° F./100° F. † 0·905-·907 @ 100° F./100° F.

TABLES OF CONSTANTS OF OILS, FATS, AND WAXES.

IV.—VEGETABLE FATS.

Name of Fat.	Sp. gr. @ 15·5/15·5° C.	Melting Point (° C.).	Hehner Value.	Saponification Value.	Iodine Value.	Butyro-refractometer (Zeiss).
Cacao butter	0·964 – ·976‡	32–34		192–195	34–38	45·6–46·5 at 40° C.
Coco-nut oil	0·910 – [illegible]	23–27	82·4–90	254–262	8–9·5	35·5 at 40° C.
Japan wax	0·984 – ·993	50·4–56	90–91·5	214–[illegible]	4·2–11	
Nutmeg butter (mace butter)	0·945 – ·996	41–51		[illegible]	[illegible]	
Palm oil	0·921 – ·924	27–42	94·5–97	[illegible]	[illegible]	[illegible] 67 @ 40° C.
Shea butter (Galam butter)	0·9175 – ·918	23–28	94·8	[illegible]	[illegible]	

V.—WAXES.

Name of Wax.	Sp. gr. @ 15·5/15·5° C.	Melting Point (° C.)	Acid Value.	Saponification Value.	Iodine Value.	Butyro-refractometer (Zeiss).
Beeswax	0·958 – ·973	6[illegible]	18–21	90–100	7–8	43·[illegible] @ 40° C.
Carnauba wax	0·995–1·000	83–86	4–8	79–84	13·5	[illegible] @ 40° C.
Chinese wax (Insect wax)	0·970	81–83	[illegible]	[illegible]	1·4	
Spermaceti	0·945–·960	42–44	0–1·8	122–135	4·4	
Sperm oil†	0·875–·884	[illegible]	[illegible]	124–144	81–87	[illegible] @ 40° C.
Wool-fat (Lanolin)	0·973	36–41	[illegible]–2·8	[illegible]	17–27	

‡ ·853–·865 @ 99/15·5 C.

* At 100° F./100° F.

† Unsaponifiable matter 38–41 %. Fatty acids 57–[illegible]

ADDENDA.

Name of oil.	Sp. gr. at 15·5°/15·5° C.	Saponification value.	Iodine value	Butyro refractometer.
Chinese wood (Tung) (D)	0·910–·914	192–196	166–176	†
Palm kernel . .	0·866–·873*	241–250	15–23	36·5 @ 40° C.
Soya bean (D) .	0·924–·927	190–193	126–135	63 @ 40° C.
Whale . .	0·917–·927	187–190	110–125	56–59 @ 40° C.

* At 99°/15·5° C. † Ref. index at 20°, 1·518.

TABLE SHOWING REICHERT-MEISSL VALUES FOR CERTAIN OILS, FATS, AND WAXES.

(c.c. N/10 alkali required by 5 grams.)

Almond oil . . .	0·5	Neat's foot oil .	0·9–1·2
Apricot kernel oil . .	0·0	Niger seed oil	0·11–0·63
Arachis oil .	0·0–1·6	Nutmeg butter .	1–4·2
Beeswax . .	0·34–0·54	Olive oil . . .	0·6
Cacao butter . .	1·0	Palm oil . . .	0·8–1·9
Castor oil . .	1·1	Palm-kernel oil .	5–6·8
Coco-nut oil . . .	6·5–8	Rape oil .	0·0–0·8
Cod-liver oil .	0·4–0·8	Sesame oil . .	1·2
Cotton-seed oil .	0·7–0·9	Soya bean oil	below 1
Croton oil . .	12–13·5	Sperm oil . .	0·6
Lard . . .	0·5–0·77	Tallow . . .	0·5
Linseed oil . . .	0·0	Whale oil . . .	0·7–2·0
Maize oil	4–4·5	Wheat oil . . .	2·5

AVERAGE POLENSKE VALUES OF OILS.

Arachis, cacao, cotton, Chinese vegetable tallow, hempseed, lard, linseed maize, niger, olive, palm, poppyseed, rape, sesame, soya, stearine, sunflower, tallow—each below 1.

Butterfat	2·3	Margarine containing no coco-nut oil . .	0·5
Coco-nut	16·5	Cacao butter . . .	0·5
Palm kernel . . .	10–12		
Oleo-oil	0·55		

OILS AND FATS.

TABLE OF SAPONIFICATION VALUES.

5 Grams Saponified.

1 c.c. N/2 acid = 0·02805 gram KOH (log. 2·44793).

No. of c.c. N/2 acid used.	Saponification value.	No. of c.c. N/2 acid used.	Saponification value.
	+0·1 c.c. = +0·56		+0·1 c.c. = +0·56
30·0	168·30	31·0	173·91
·2	169·42	·2	175·03
·4	170·54	·4	176·15
·6	171·67	·6	177·28
·8	172·79	·8	178·40

OILS AND FATS.

TABLE OF SAPONIFICATION VALUES—*continued.*

5 Grams Saponified

1 c.c. N/2 acid = 0·02805 gram KOH log. 2·44793

No. of c.c. N/2 acid used	Saponification value.	No. of c.c. N/2 acid used	Saponification value.
	0·1 c.c. = 0·56		0·1 c.c. = 0·56
32·0	179·52	37·8	212·06
·2	180·64	38·0	213·18
·4	181·76	·2	214·30
·6	182·89	·4	215·42
·8	184·01	·6	216·55
33·0	185·13	·8	217·67
·2	186·25	39·0	218·79
·4	187·37	·2	219·91
·6	188·50	·4	221·03
·8	189·62	·6	222·16
34·0	190·74	·8	223·28
·2	191·86	40·0	224·40
·4	192·98	·2	225·52
·6	194·11	·4	226·64
·8	195·23	·6	227·77
35·0	196·35	·8	228·89
·2	197·47	41·0	230·01
·4	198·59		
·6	199·72	1·0	5·61
·8	200·84	2·0	11·22
36·0	201·96	3·0	16·83
·2	203·08	4·0	22·44
·4	204·20	5·0	28·05
·6	205·33	6·0	33·66
·8	206·45	7·0	39·27
37·0	207·57	8·0	44·88
·2	208·69	9·0	50·49
·4	209·81	10·0	56·10
·6	210·94		

The *Saponification Equivalent* of a fat is the number of grams that would be saponified by 1 litre of a normal solution of *any* alkali. It is the quotient obtained by dividing 56108 by the saponification value.

BUTYRO REFRACTOMETER.—TABLE FOR CONVERSION OF SCALE READINGS INTO REFRACTIVE INDICES (n_D) FOR YELLOW LIGHT.*

Scale reading	n_D	Scale reading	n_D	Scale reading	n_D
10	1·4300	49	1·4586	72	1·4735
15	1·4338	50	1·4593	73	1·4741
20	1·4377	51	1·4600	74	1·4747
25	1·4415	52	1·4606	75	1·4753
30	1·4452	53	1·4613	76	1·4759
31	1·4459	54	1·4619	77	1·4765
32	1·4466	55	1·4626	78	1·4771
33	1·4474	56	1·4633	79	1·4777
34	1·4481	57	1·4639	80	1·4783
35	1·4488	58	1·4646	81	1·4789
36	1·4495	59	1·4652	82	1·4794
37	1·4502	60	1·4659	83	1·4800
38	1·4510	61	1·4665	84	1·4806
39	1·4517	62	1·4672	85	1·4812
40	1·4524	63	1·4678	86	1·4817
41	1·4531	64	1·4685	87	1·4823
42	1·4538	65	1·4691	88	1·4829
43	1·4545	66	1·4697	89	1·4834
44	1·4552	67	1·4704	90	1·4840
45	1·4559	68	1·4710	95	1·4868
46	1·4565	69	1·4717	100	1·4895
47	1·4572	70	1·4723		
48	1·4579	71	1·4729		

Correction for Temperature (Wright †).—The following formula is applicable to all fatty oils:

Let n_t be the refractive index at t° C.

$n_{t'}$,, ,, t'°.

Then

$$n_{t'} = (n_t - 1) \times \frac{1 - 0·00076t'}{1 - 0·00076t} + 1.$$

Where $t' = 40$° C. the formula becomes

$$n_{40} = (n_t - 1) \times \frac{0·9696}{1 - 0·00076t} + 1.$$

Ex. Olive oil. Ref. index at 30° C. is 1·4657.

Then

$$n_{40} = 0·4657 \times \frac{0·9696}{1 - 0·00076 \times 30} + 1 = 1·4621.$$

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[*] The values here given have been obtained by interpolation from the short table supplied by Zeiss with each instrument.

[†] See *Journ. Soc. Chem. Ind.*, 1919, 38, 392 T.

SOLUBLE OR VOLATILE ACIDS IN BUTTER FAT.

5 Grams Butter Fat being taken.

c.c. $\frac{N}{10}$ Alkali.	% Soluble or Volatile Acids *	c.c. $\frac{N}{10}$ Alkali.	% Soluble or Volatile Acid	c.c. $\frac{N}{10}$ Alkali.	% Soluble or Volatile Acids.
1·0	0·18	13·5	2·38	26·0	4·58
1·5	0·26	14·0	2·46	26·5	4·66
2·0	0·35	14·5	2·55	27·0	4·75
2·5	0·44	15·0	2·64	27·5	4·84
3·0	0·53	15·5	2·73	28·0	4·93
3·5	0·62	16·0	2·82	28·5	5·02
4·0	0·70	16·5	2·90	29·0	5·10
4·5	0·79	17·0	2·99	29·5	5·19
5·0	0·88	17·5	3·08	30·0	5·28
5·5	0·97	18·0	3·17	30·5	5·37
6·0	1·06	18·5	3·26	31·0	5·46
6·5	1·14	19·0	3·34	31·5	5·54
7·0	1·23	19·5	3·43	32·0	[illegible]
7·5	1·32	20·0	3·52	32·5	5·72
8·0	1·41	20·5	3·61	33·0	5·81
8·5	1·50	21·0	3·70	33·5	5·90
9·0	1·58	21·5	3·78	34·0	5·98
9·5	1·67	22·0	3·87	34·5	6·07
10·0	1·76	22·5	3·96	35·0	6·16
10·5	1·85	23·0	4·05		
11·0	1·94	23·5	4·14	0·1	0·02
11·5	2·02	24·0	4·22	0·2	0·04
12·0	2·11	24·5	4·31	0·3	0·05
12·5	2·20	25·0	4·40	0·4	0·07
13·0	2·29	25·5	4·49		

* Calculated as Butyric Acid $C_4H_8O_2$ = 88

LIMIT OF BUTTER-FAT ALLOWED IN MARGARINE.

Section 8 of the "Sale of Food and Drugs Act, 1899" enacts that it is unlawful to manufacture, sell, or import any margarine the fat of which contains more than 10 per cent. of butter fat.

BUTTER AND MARGARINE ACT, 1907.

The following provisions of the above are of importance to the Public Analyst:—

Section 4 (1) fixes the limit of water in butter and margarine at 16 per cent., and by sub-section (2) the limit of water in milk-blended butter is 24 per cent.

Section 13 is as follows: (1) For the purposes of the Sale of Food and Drugs Acts and this Act the expression "Margarine" shall mean any article of food, whether mixed with butter or not, which resembles butter and is not milk-blended butter. (2) The above definition shall be substituted for the definition of margarine in the Margarine Act, 1887. This latter was as follows: The word "Margarine" shall mean all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed with butter or not.

TABLE SHOWING THE VARIATIONS IN REICHERT-WOLLNY NUMBER, ETC., OF BUTTER AND MARGARINE.†

	Butter.		Margarine.
	Mean.	Variations.	
Reichert-Wollny number	28·4 c.c.	21·2–35 c.c.	0·0–0·3 c.c.
Insoluble fatty acids	87·75%	85·6–89·6%	95–96%
Soluble fatty acids	5·58%	4·6–7·0%	trace
Butyro-refractometer (Zeiss) at 35° C.	46·0	43·8–49	52–56
Iodine absorption	37·1%	31·6–42·0%	50–60%
Sp. gr. 100° F/100°	0·9117	0·9105–·9122	0·901–·903
Potash absorption	22·58%	22·01–22·98%	19·4–19·6%

THE INTERDEPENDENCE OF THE PHYSICAL AND CHEMICAL CRITERIA IN THE ANALYSIS OF BUTTER-FAT.

During 1901–2 over four hundred samples of butter were taken from farms or creameries in various parts of the United Kingdom, including the Orkneys, Shetlands and Hebrides, the samples being specially selected with the view of ascertaining by analysis the extent to which the chemical nature of butter-fat is dependent on the climatic influences to which the cows are exposed, on the nature and amount of the food supplied, and on the breed, period

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* From the Report of the official method for determining the percentage of butter-fat in margarine (see *The Analyst*, 1900, p. 510).

† By H. Droop Richmond, see Appendix XXI. to the *Final Report of the Departmental Committee on Butter Regulations*, 1904.

of lactation, and idiosyncrasy of the individual cow. Of the samples collected, 357 were fully analysed in the Government Laboratory, and the results, which are fully recorded in supplements to the report already referred to, form the subject of a paper with the above title* by Dr T. E. Thorpe, C.B., F.R.S. The results are summarized in the subjoined table:—

Butter-fat.	357 samples examined		
	39 samples ([illegible])	290 samples (81·[illegible])	28 samples (7·9)
Reichert - Wollny number	22·5 - 24·5	25·5 - 30·5	31·3 - 32·6
Sp. gr. 100° F./100° F.	0·9104 - ·9108	0·9110 - ·9123	0·9125 - ·9130
Saponification equivalent	[illegible] - 253·8	251·1 - 242·4	241·5 - 241·2
(Koettstorfer number)	[illegible] - 222·8	223·0 - 231·0	231·9 - 232·2
Butyro - refractometer (Zeiss) at 45° C.	42·[illegible] - 41·5	41·3 - 39·9	39·7 - 39·4
Soluble acids† %	[illegible] - 4·7	4·8 - 5·7	5·8 - 6·0
Insoluble acids %	90·1 - 89·4	89·3 - 87·9	[illegible]·9 - 87·7

Dr Thorpe makes the following comments:—

"It will be seen that, in a general sense, the relative density of butter-fat increases as the Reichert-Wollny number is augmented.‡ This would, of course, follow from the well-known fact that the glycerides of low molecular weight have a greater density than the glycerides of the higher fatty acids which occur in butter." . . . "Speaking broadly, the variations of the saponification numbers are in inverse relation to those of the Reichert-Wollny values and the relative densities.‡ . . . The Zeiss numbers generally decrease in magnitude as the Reichert-Wollny values increase, but the rate of diminution is not regular."‡

BOARD OF AGRICULTURE RULES.

Sale of Butter Regulations, 1902.

Where the proportion of water in a sample of butter exceeds 16 per cent., it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the butter is not genuine by reason of the excessive amount of water therein.

This regulation extends to Great Britain, and came into operation on 15th May 1902.

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* *Journ. Chem. Soc.*, 1904, pp. 248-256.

† Calculated as butyric acid.

‡ These relations are deduced from curves plotted from the averages of the various analytical results.

The Departmental Committee on butter regulations, in their Final Report, dated 1st December 1903, recommend :—

(1) That the figure 24, arrived at by the Reichert-Wollny method, should be the limit below which a presumption should be raised that butter is not genuine.

(2) That the use of 10 per cent. of sesamé oil in the manufacture of margarine be made compulsory.

(3) That steps should be taken to obtain international co-operation.

Two members of the Committee, however, favoured the Reichert-Wollny number of 23 instead of 24. A third member, who did not sign the Report of the majority, stated in a separate report that he considered it would be "highly dangerous" to fix any limit at present.

CALCULATION OF THE RESULTS OF MILK ANALYSES.

According to the "Sale of Milk Regulations 1901" (see p. 153), milk is to be presumed not to be genuine if the non-fatty solids fall below 8·5 per cent., or the milk-fat below 3 per cent.

The calculation of the amount of added water in the case of samples whose non-fatty solids fall below the above limit is made as follows :—

Since 8·5 parts of non-fatty solids correspond to 100 parts of genuine (*i.e.*, *presumably* genuine) milk, S parts of non-fatty solids correspond to $\frac{100}{8{\cdot}5} \times S$ of genuine milk ; and 100 parts of the watered sample will contain

$$100 - \frac{100\,S}{8{\cdot}5} = \frac{100}{8{\cdot}5}(8{\cdot}5 - S) \text{ of added water.}$$

Since log. $\frac{100}{8{\cdot}5} = 1{\cdot}07058$, we have

log. of percentage of added water = 1·07058 + log. (8·5 − per cent. of non-fatty solids found).

We will now consider two examples.

	Example I.	Example II.
Non-fatty solids .	7·60 per cent.	7·89
Fat	2·80 "	2·25

Example I. 8·50 − 7·60 = 0·90.

$$\begin{array}{ll} & 1{\cdot}07058 \\ \text{log. } 0{\cdot}9 & \bar{1}{\cdot}95424 \\ \hline & 1{\cdot}02482 = \text{log. } 10{\cdot}6 \end{array}$$

∴ at least 10 per cent. of added water.

A mixture of 90 parts of genuine milk and 10 parts of added water should contain $\frac{90}{100} \times 3 = 2{\cdot}7$ per cent. at least of fat. The sample contains 2·8 per cent., and hence contains proportionately a little more fat than that given in the Regulation.

Example II 8·50 – 7·89 = 0·61.
1·07058
log. 0·61 = 1·78533

0·85591 = log. 7·2, ∴ at least 7 per cent. of added water.

A mixture of 93 parts of genuine milk and 7 parts of added water should contain 0·93 × 3 = 2·79 per cent. at least of fat. The sample contains only 2·25 per cent., and is, therefore, $\frac{100(2·79 - 2·25)}{2·79}$ = 19 per cent. deficient in milk fat as well.

Or thus: In this case 93 parts of "milk" contain 2·25 parts of fat, or 100 parts would contain $\frac{100 \times 2·25}{93}$ = 2·42 of fat, which is below the minimum allowed. Hence the milk had been deprived of $\frac{100(3 - 2·42)}{3}$ = 19 per cent. of its fat in addition to being watered to the extent of 7 per cent.

BOARD OF AGRICULTURE RULES

Sale of Milk Regulations, 1901.

Milk.

1. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed, milk) contains less than 3 per cent. of milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk-fat, or the addition thereto of water.

2. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed, milk) contains less than 8·5 per cent. of milk-solids other than milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk-solids other than milk-fat, or the addition thereto of water.

The above Regulations, which extend to Great Britain, came into force on Sept. 1, 1901, and still hold good.

Regulation 3, however, was revoked by "The Sale of Milk Regulations, 1912," and the following substituted for it:—

Skimmed or Separated Milk.

Where a sample of skimmed or separated milk (not being condensed milk) contains less than 8·7 per cent. of milk solids other than milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1907, until the contrary is proved, that the milk is not genuine, by reason of either the addition thereto of water, or the abstraction therefrom of milk solids other than milk-fat.

This Regulation extends to England and Wales, and came into operation on Sept. 1, 1912.

TABLE GIVING THE PERCENTAGE DEFICIENCY OF NON-FATTY SOLIDS (N.F.S.) IN MILK IN WHICH THESE ARE BELOW THE LEGAL MINIMUM OF 8·5 PER CENT.

Non-fatty Solids.	Deficiency in N.F.S.	% Non-fatty Solids.	Deficiency in N.F.S.	% Non fatty Solids.	Deficiency in N.F.S.
4·0	52·94	5·5	35·29	7·0	17·65
·1	51·76	·6	34·12	·1	16·47
·2	50·59	·7	32·94	·2	15·29
·3	49·41	·8	31·76	·3	14·12
·4	48·24	·9	30·59	·4	12·94
·5	47·06	6·0	29·41	·5	11·76
·6	45·88	·1	28·24	·6	10·59
·7	44·71	·2	27·06	·7	9·41
·8	43·53	·3	25·88	·8	8·24
·9	42·35	·4	24·71	·9	7·06
5·0	41·18	·5	23·53	8·0	5·88
·1	40·00	·6	22·35	·1	4·71
·2	38·82	·7	21·18	·2	3·53
·3	37·65	·8	20·00	·3	2·35
·4	36·47	·9	18·82	·4	1·18

	·01	·02	·03	·04	·05	·06	·07	·08	·09
Subtract	·12	·23	·35	·47	·59	·71	·82	·94	1·06

Ex.—A sample of "milk" containing 7·26% of non-fatty solids would thus show a deficiency of 15·29 – ·71 = 14·58 %.

TABLE SHOWING THE DEFICIENCY IN FAT IN CREAMED MILK.

% Milk-fat.	% Deficiency in Fat.	% Milk fat.	% Deficiency in Fat.	% Milk-fat.	% Deficiency in Fat.
0·1	96·67	1·1	63·33	2·1	30·00
·2	93·33	·2	60·00	·2	26·67
·3	90·00	·3	56·67	·3	23·33
·4	86·67	·4	53·33	·4	20·00
·5	83·33	·5	50·00	·5	16·67
·6	80·00	·6	46·67	·6	13·33
·7	76·67	·7	43·33	·7	10·00
·8	73·33	·8	40·00	·8	6·67
·9	70·00	·9	36·67	·9	3·33
1·0	66·67	2·0	33·33	...	...

	·01	·02	·03	·04	·05	·06	·07	·08	·09
Subtract	0·33	0·67	1·00	1·33	1·67	2·00	2·33	2·67	3·00

MILK ANALYSIS.

Table to find the sp. gr. of Milk at 60° Fah. from its sp. gr. at any Temperature between 50° and 70° Fah. (water=1000).

*Fah.	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035
50	19·2	20·2	21·2	22·2	23·2	24·1	25·1	26·1	27·0	28·0	29·0	29·9	30·9	31·8	32·7	33·6
51	·3	·3	·3	·3	·3	·2	·2	·2	·1	·1	·1	30·0	31·0	·9	·9	·8
52	·4	·3	·3	·3	·3	·3	·2	·2	·2	2	·1	·1	·1	32·0	33·0	·9
53	·4	·4	·4	·4	·4	·4	·3	·3	·3	·3	·2	·2	·2	·1	·1	34·0
54	·5	·5	·5	·5	·5	·5	·4	·4	·4	·4	·3	·3	·3	·2	·2	·2
55	·6	·6	·6	·6	·6	·6	·5	·5	·5	·5	·4	·4	·4	·4	·3	·3
56	·7	·7	·7	·7	·6	·6	·6	·6	·6	·6	·5	·5	·5	·5	·5	·5
57	·8	·8	·8	·8	·7	·7	·7	·7	·7	·7	·7	·6	·6	·6	·6	·6
58	·9	·9	·9	·8	·8	·8	·8	·8	·8	·8	·8	·8	·7	·7	·7	·7
59	·9	·9	·9	9	·9	·9	·9	·9	·9	9	·9	·9	·9	·9	·9	·9
60	20·0	21·0	22·0	23·0	24·0	25·0	26·0	27·0	28·0	29·0	30·0	31·0	32·0	33·0	34·0	35·0
61	·1	·1	·1	·1	·1	·1	·1	·1	·1	·1	·1	·2	2	2	·2	·2
62	·2	·2	2	2	·2	·2	·2	·3	·3	·3	·3	·3	·3	·3	·3	·3
63	·2	·3	·3	·3	·3	·3	·3	·4	4	·4	·4	·4	·5	·5	·5	·5
64	·3	·4	·4	·4	·4	·4	·5	·5	·5	·5	·5	·5	·6	·6	·6	·6
65	·4	·5	·5	·5	·5	·5	·6	·6	·6	·6	·7	·7	·7	·8	·8	·8
66	·5	·6	·6	·6	6	6	·7	·7	·7	·8	·8	·8	·9	·9	·9	·9
67	·6	·7	·7	·7	·7	·7	·8	·8	·8	·9	·9	32·0	33·0	34·0	35·0	36·1
68	·7	·8	·8	·8	·9	·9	27·0	28·0	29·0	30·1	31·1	·2	·2	·2	·2	·2
69	·9	22·0	23·0	24·0	25·0	26·0	·1	·1	·1	·2	·2	·2	·3	·3	·3	·4
70	21·0	·1	·1	·1	·1	·1	·2	·2	·2	3	·3	·4	·4	·5	·5	·5

* The observed sp. gr. is given at the top of each column, and the number in the column opposite to the temperature at which the sp. gr. was determined added to 1000 gives the sp. gr. at 60° F.

Ex. 1. Milk of which the sp. gr. is 1032 at 54° F. is 1031·3 at 60° F.

Ex. 2. Milk of which the sp. gr. is 1028·6 at 65° F. becomes 1000 + (28·4 + 0·6 = 1029 at 60° F.

PRESERVATIVES IN MILK AND CREAM.

According to the provisions of "The Public Health (Milk and Cream) Regulations, 1912," the addition of any preservative substance to milk (including separated, skimmed, condensed, and dried milk) or to cream, containing less than 35 per cent. by weight of milk-fat is prohibited. The addition of any thickening substance (*i.e.* sucrate of lime, gelatin, starch paste, etc.) to cream, whether containing preservative or not, is also prohibited. Cream containing 35 per cent. or more by weight of milk fat may contain no other preservative than (i) boric acid, borax, or a mixture of those preservative substances, or (ii) hydrogen peroxide.

By the Amending Order of the above (dated February 8, 1917) the maximum amount of boric preservative calculated as boric acid (H_3BO_3) allowed in preserved cream is 0·4 per cent. Two types of label were ordered to be used, thus (i) Preserved cream containing boric acid not exceeding per cent., (ii) Preserved cream (peroxide)—with the addition in each case of the statement "not suitable for infants or invalids." The above Order came into operation on April 2, 1917.

QUININE.

Hydrochloride of quinine,
$C_{20}H_{24}N_2O_2$, HCl, $2H_2O$.
= 396·712.

Percentage composition.

$C_{20}H_{24}N_2O_2$ . . .	81·73
HCl	9·19
H_2O	9·08
	100·00

Sulphate of quinine,
$2[(C_{20}H_{24}N_2O_2)_2.H_2SO_4]$, $15H_2O$
= 1763·24

Percentage composition.

$C_{20}H_{24}N_2O_2$ . . .	73·55
H_2SO_4 . . .	11·12
H_2O	15·33
	100·00

To convert		Multiplier	Log to be added
$C_{20}H_{24}N_2O_2$ into	$C_{20}H_{24}N_2O_2$, HCl, $2H_2O$	1·2236	0·087 65
" "	$2[(C_{20}H_{24}N_2O_2)_2.H_2SO_4]$, $15H_2O$	1·360	0·133 43

Tincture of quinine, B.P. 1914, contains 2 grams of quinine hydrochloride in 100 c.c.

E. W. T. JONES'S METHOD FOR THE ESTIMATION OF CHICORY IN MIXTURES OF COFFEE AND CHICORY.

The sample is dried in the water-oven, and 5 grams are weighed into a large porcelain dish. About 200 c.c. of water are added, and boiled for 15 minutes. After allowing a minute or two for settling, the liquid is strained through a piece of copper gauze placed in a funnel into a 250 c.c. measuring flask, care being taken to disturb the grounds as little as possible. The latter are now treated with about 50 c.c. of water, boiled for 5 minutes, and the liquid strained off as before. The flask is then cooled, made up to the mark, well shaken and filtered, the liquid being poured on a *dry* filter; 50 c.c. of the filtrate (= 1 gram of the coffee mixture) are then pipetted into a weighed, flat-bottomed glass dish, evaporated to dryness over a steam-bath, and finally dried in the water-oven. The results are returned to the nearest percentage of chicory (see Table on p. 158).

Treated as above chicory gives a mean percentage extract of 70; while coffee gives a remarkably constant percentage extract of 24.

To determine the percentage of chicory from the weight of extract obtained, we proceed as follows:—

Let x = percentage of chicory.
∴ $100 - x$ = " " coffee,
and let E = " " extract found.

$$\therefore 0{\cdot}7x + {\cdot}24(100 - x) = \text{E}$$
$$0{\cdot}7x + 24 - {\cdot}24x = \text{E}$$
$${\cdot}46x = \text{E} - 24.$$
$$x = \frac{\text{E} - 24.}{{\cdot}46}$$

Putting $x = 1$, we find E = 24·46, and the table on page 158 is in this way easily calculated.

Note.—By the above method E. W. T. Jones obtained the excellent results recorded in *The Analyst*, 1882, 7, 76, in the case of the Birkenhead "Coffee" samples.

LEAD IN TARTARIC AND CITRIC ACIDS AND IN CREAM OF TARTAR.

Dr MacFadden, in a Report to the Local Government Board,* recommends the adoption of a limit of 0·002 per cent. (approximately $\frac{1}{7}$th grain per lb.) of lead as impurity in tartaric acid, citric acid, and cream of tartar.

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* Report (No. 2) on Lead and Arsenic in Tartaric Acid, Citric Acid and Cream of Tartar, 1907.

TABLE SHOWING THE PERCENTAGE OF CHICORY WITH COFFEE FROM THE PERCENTAGE OF AQUEOUS EXTRACT.

Extract per cent.	Chicory per cent.	Extract per cent.	Chicory per cent.	Extract per cent.	Chicory per cent
24·46	1	40·10	35	55·28	68
·92	2	·56	36	·74	69
25·38	3	41·02	37	56·20	70
·84	4	·48	38	·66	71
26·30	5	·94	39	57·12	72
·76	6	42·40	40	·58	73
27·22	7	·86	41	58·04	74
·68	8	43·32	42	·50	75
28·14	9	·78	43	·96	76
·60	10	44·24	44	59·42	77
29·06	11	·70	45	·88	78
·52	12	45·16	46	60·34	79
·98	13	·62	47	·80	80
30·44	14	46·08	48	61·26	81
·90	15	·54	49	·72	82
31·36	16	47·00	50	62·18	83
·82	17	·46	51	·64	84
32·28	18	·92	52	63·10	85
·74	19	48·38	53	·56	86
33·20	20	·84	54	64·02	87
·66	21	49·30	55	·48	88
34·12	22	·76	56	·94	89
·58	23	50·22	57	65·40	90
35·04	24	·68	58	·86	91
·50	25	51·14	59	66·32	92
·96	26	·60	60	·78	93
36·42	27	52·06	61	67·24	94
·88	28	·52	62	·70	95
37·34	29	·98	63	68·16	96
·80	30	53·44	64	·62	97
38·26	31	·90	65	69·08	98
·72	32	54·36	66	·54	99
39·18	33	·82	67	70·00	100
·64	34				

FOOD PRESERVATIVES.

The Departmental Committee on Food Preservatives appointed in 1899 in their Report,* issued in 1901, make the following recommendations:—

(*a*) That the use of formaldehyde or formalin, or preparations thereof, in food or drinks be absolutely prohibited, and that salicylic acid be not used in a greater proportion than 1 grain per pint in liquid food and 1 grain per pound in solid food. Its presence in all cases to be declared.

(*b*) That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Acts.†

(*c*) That the only preservative which it shall be lawful to use in cream be boric acid, or mixtures of boric acid and borax, and in amount not exceeding 0·25 per cent. expressed as boric acid. The amount of such preservative to be notified by a label upon the vessel.

(*d*) That the only preservative permitted to be used in butter and margarine be boric acid or mixture of boric acid and borax, to be used in proportion not exceeding 0·5 per cent. expressed as boric acid.

(*e*) That in the case of all dietetic preparations intended for the use of invalids or infants, chemical preservatives of all kinds be prohibited.

(*f*) That the use of copper salts in the so-called greening of preserved foods be prohibited.

(*g*) That means be provided either by the establishment of a separate court of reference, or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matters in foods, and to prepare schedules of such as may be considered inimical to the public health.

With regard to the recommendation marked (*f*), Dr Tunnicliffe, a member of the Committee, points out the value of appearance in rendering foods appetising, and recommends that not more than the equivalent of half a grain of metallic copper per pound should be allowed to be added, the actual amount used being declared.

ARSENIC IN FOOD.

In the Final Report of the Royal Commission appointed to inquire into Arsenical Poisoning, issued in November 1903, the Commissioners state (Part VIII., p. 50), that "In our view it would be entirely proper that penalties should be imposed under the Sale of Food and Drugs Acts upon any vendor of beer or any other liquid food, or of any liquid entering into the composition

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[*] *Report of Departmental Committee on Preservatives and Colouring Matters in Food*, 1901, pp. xxx and xxxi.

[†] See also Circular issued by the Local Government Board, July 11, 1906 (reprinted in *The Analyst*, 1906, **31**, 278).

of food, if that liquid is shown by an adequate test to contain $\frac{1}{100}$th of a grain or more of arsenic in the gallon; and, with regard to solid food—no matter whether it is habitually consumed in large or in small quantities, or whether it is taken by itself (like golden syrup) or mixed with water or other substances (like chicory or 'carnos')—if the substance is shown by an adequate test to contain $\frac{1}{100}$th grain of arsenic or more in the pound."

Note. In the above "arsenic" is taken to mean *arsenious oxide* (As_4O_6).

HEAT AND THERMO CHEMISTRY.

The C.G.S. unit of heat is the calorie, which is the quantity of heat required to raise 1 gram of water through 1° C.

The large or major calorie is the quantity of heat required to raise 1 kilogram of water through 1° C. in the neighbourhood of 15° C. This is the metric unit of heat adopted for technical purposes and is known as the K.C.U.

The British Thermal Unit (B.Th.U.) is the amount of heat required to raise 1 lb. of water through 1° Fah. in the neighbourhood of 60° F. Hence

1 K.C.U. = 3·9683* (or approximately 4) B.Th.Us.
1 B.Th.U. = 0·252 (or approximately $\frac{1}{4}$) K.C.U.

The "Pound Centigrade Unit" is the quantity of heat required to raise 1 lb. of water 1° C.

The ratio of this unit to the B.Th.U. is obviously that of the degree Centigrade to the degree Fahrenheit, viz. 5 : 9 or 1 : 1·8, and 1 B.Th.U. = $\frac{5}{9}$ = 0·555 lb. Centigrade Unit. To convert lb. Cent. Units into B.Th.U. multiply by two and subtract one-tenth. Thus 8000 of the former = 16,000 − 1600 = 14,400 B.Th.U.

The Evaporative Power (E.P.) of fuel is the number of pounds of water at 212° F., which would be converted into steam by the combustion of 1 lb. of fuel. The latent heat of vaporization of water is 537 Centigrade or 967 Fahrenheit units, hence

$$E.P. = \frac{B.Th.U.}{967} = \frac{\text{calorific power in calories}}{537}.$$

The values of the mechanical equivalent of heat, that is, the number of units of mechanical work equivalent to one unit of heat, or Joule's equivalent (designated by the letter J), are usually taken to be as follows:—

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* Thus, the quantity of heat that will raise 1 kilog. through 1° C. will raise its equivalent, 2·2046 lb., through 1·8° F., or 1 lb. through 2·2046 × 1·8 = 3·968° F.

777 foot-pounds are equivalent to 1 B.Th.U. (lb. deg. Fah.).
1399 " " " 1 lb. deg. C.
426·3 kilogrammetres " " 1 kilogram-deg. C. or kilo-calorie.
4·180 joules* " 1 gram-deg. C. or calorie.

The water for the heat units is supposed to be taken at 20° C. (68° F.) and the degree of temperature is supposed to be measured by the hydrogen thermometer.

Heat evolved in calories (water-gram degrees) on burning 1 gram of:—

Hydrogen to water at 20° C.	34,000
Carbon to carbon dioxide	8,080
" " monoxide	2,116
Alcohol (absolute)	7,184
Anthracite	9,200-9,500
Briquettes	2,800-3,300
Bituminous coal	8,000-9,600
Coke (dry)	7,100-6,860
Wood (with 20 per cent. water)	2,500-5,000
Wood charcoal	[illegible]-7,000
Lignite	[illegible]-7,000
Peat (air dried)	[illegible]
Light petroleum (sp. gr. 0·7[illegible]-0·705)	11,300-[illegible]
Petrol (sp. gr. 0·684)	11,52[illegible]
Petroleum	10,960
Shale oil, Tar oil, and Creosote oil	8,800
Methylated spirit	6,200

Liquid fuels range from 9000-11,000 calories per gram.

Note. The above figures also give calorific values in pound-centigrade units per lb. of substance burnt.

The following results are useful:—

Fuel.	Sp. gr.	B.Th.U. per lb.	B.Th.U. per gallon.
Petrol	0·738	18,750	138,375
Benzole (90 per cent.)	0·872	17,830	155,478
" "	0·8[illegible]7	17,6[illegible]	155,[illegible]40

In the case of fuels containing hydrogen (*e.g.* coal) the *gross* calorific value (the one usually employed) is that in which the heat liberated by the condensation of the steam produced on combustion and by the subsequent cooling of the condensed water down to 60° F., is included. When the two last named amounts of heat are not included, the net calorific value is obtained. In most calorimeters the water produced by combustion is condensed.

The latent heat of water is 80 (gram-deg. C.) or 144 in B.Th.U.

The latent heat of steam is 537 (gram deg. C.) or 967 in B.Th.U.

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* The joule is the practical unit of work in the C.G.S. system. It equals 10 million (or 10^7) absolute units of work (ergs).

THE DETERMINATION OF THE CALORIFIC POWER OF FUEL BY THOMPSON'S CALORIMETER.

Although recent comparative experiments with different types of calorimeter * have conclusively proved the superiority of Mahler's Bomb Calorimeter above all other forms, still, owing to the expense of the instrument, it seems unlikely to come into general use at present. And since Thompson's Calorimeter is so largely used, the following details of manipulation are given, so that the best results the instrument is capable of giving may be obtained.†

In the first place it should be noted that for coals of an anthracitic character, yielding more than 87 per cent. of coke, or for coke itself, Thompson's Calorimeter is not suited as an indicator of their comparative calorific power, for the simple reason that some of the carbon is so graphitic in its nature that it will not burn perfectly when mixed with nitrate and chlorate of potash; but with bituminous and semi-bituminous coals the apparatus yields very satisfactory results.

Preparation of the sample of coal.—Sample the coal until an average portion passes through an 8-mesh sieve. Take about 20 grains of this and run through a 68-mesh sieve, taking care that the whole sample selected is thus treated. Then dry at 100° C., and use the dried coal for making the determination.

Preparation of the oxidizing mixture.—Potassium nitrate and chlorate are used in the proportion of 1 part of nitrate to 3 of chlorate. These are first thoroughly dried, ground separately, and sifted through a 30-mesh sieve—a finer powder being prejudicial. The powders are then mixed in the proportions stated, and kept in a well-stoppered bottle.

Preparation of the wick. Oxford cotton is soaked in a moderately strong solution of potassium nitrate, and dried. When dry, it should burn a little too quickly. It should then be rubbed between two pieces of cloth until it burns just freely enough. Four cotton strands are twisted together, cut into ¾-inch lengths, thoroughly dried, and put into a bottle.

The process.—Before weighing out the coal, etc., read the temperature of the room, and regulate the temperature of the water used by the following table.

Temperature of room.	Water should be at.
80° F. (26·7° C.)	70° F. (21·1° C.)
72° (22·2° C.)	64° (17·8° C.)
67° (19·4° C.)	60° (15·6° C.)
60° (15·6° C.)	54° (12·2° C.)
55° (12·8° C.)	50° (10° C.)
50° (10° C.)	46° (7·8° C.)
42° (5·6° C.)	40° (4·4° C.)

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* See paper by Brame and Cowan, *J.S.C.I.*, 1903, p. 1230.

† The details given are condensed from the valuable paper by J. W. Thomas in the *Chemical News*, 25th March 1881, p. 135, with additions by the author.

Instead of simply filling up to the 29,010 grain mark, it is more accurate to measure out 2 litres, *less* 116 c.c., since 29,010 grains of water occupy 1884 c.c. A tall narrow cylinder with a single mark serves to measure the 116 c.c. to be withdrawn from the second litre before pouring in. Put a thermometer into the water and leave it there while weighing out the coal. 30 grains of the dried coal are intimately mixed with 330 grains of the oxidizing mixture; best with a spatula rather than in a mortar. Introduce the mixture into the cylinder (3½″ × [illegible]″), pressing down in small portions at a time with a test tube; do not [illegible] up. Put in the fuse, opening out its lower end in the mixture. Then read the thermometer, light the fuse and place the cylinder, with its stand and cover, quickly in the jar. The combustion should occupy between one and two minutes. At its conclusion the stopcock is opened and the whole moved up and down in the liquid with the thermometer, the latter being read three or four times, and its maximum reading noted. An example will show the mode of calculating results.

Temperature of room	60° F.
" water after combustion	67·1
" before combustion	54·4
Increase	[illegible]
+ $\frac{1}{10}$*	[illegible]
Evaporative power of the coal, *i.e.* number of lb. of water at 212° F. evaporated by 1 lb. of the dried coal	13·97

13·97 × 537 = 7502 calories, *i.e.* grams of water heated 1° C. by 1 gram of the coal.

13·97 × 967 = 13509 British Thermal Units, or number of lb. of water heated through 1° Fah. by 1 lb. of the coal.

The evaporative power of the coal in its original state can be calculated as follows:—

Suppose the above coal to have 11·5 per cent of moisture,
then 1 lb. contains ·885 lb. of dry coal,
and ·115 lb. of moisture,

$$\cdot885 \times 13\cdot97 = 12\cdot36.$$

The quantity of heat required to raise 0·115 lb. of water from 60° to 212° F., and to convert the boiling water into steam, is

$$(152 + 967) \times \cdot115 \text{ pound-degree Fah. units,}$$

which has an evaporative power of

$$\frac{1119 \times \cdot115}{967} \quad 0\cdot13 \text{ lb.}$$

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* An addition of 10 per cent. is made to allow for the heat absorbed by the copper cylinder and stand and for carbon not completely burned. It has been found to be too small in most cases, and an increase to 15 per cent. has been suggested by Scheurer-Kestner.

Hence the evaporative power of the original coal is 12·36 − ·13 = 12·23 lb.

Since $\frac{1119}{967} = 1·16$, the amount to be finally deducted is obtained by simply multiplying this number by the amount of water contained in 1 lb. of coal.

When the ultimate analysis of a dry coal is known, the calorific value (in calories) can be *approximately* calculated by the following formula:

$$Q = \frac{1}{100}\left\{8140\,C + 34500\left(H - \frac{(O+N) - 1}{8}\right) + 2220\,S\right\}$$

$$= 81·4\,C + 43·125\,\{8\,H - (O+N) + 1\} + 22·2\,S.$$

Thus, the analysis of a *dry* coal gave

C 90·09 ; H 3·85 ; (O+N) 3·61 ; S 0·77.

$$\text{Hence } Q = 81·4 \times 90·09 + 43·125\,\{8 \times 3·85 - 3·61 + 1\} + 22·2 \times ·77$$

$$= 7333 + 1216 + 17$$

$$= 8566$$

Mahler's calorimeter gave 8629 calories.

ELECTRICAL UNITS.

The *ohm* is the resistance offered to an unvarying electric current by a column of mercury at 0° C., 14·4521 grams in mass, of a constant cross-sectional area, and of a length of 106·3 cm.

The *ampere* is represented by the unvarying electric current which, when passed through a 10 per cent. aqueous solution of silver nitrate, deposits silver at the rate of 0·001118 gram per second.

The *volt* is the electrical pressure that, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere, and which is represented by 0·6974 $\left(\frac{1000}{1434}\right)$ of the electrical pressure at 15° C. between the poles of a standard Clark's Cell.

TABLE OF ELECTRO-CHEMICAL EQUIVALENTS.

(In grams per coulomb.*)

Hydrogen . .	0·00001034	Iron (ous) . . .	0·0002902
Potassium . .	0·0004053	,, (ic) .	0·0001935
Sodium . .	0·0002388	Nickel . . .	0·0003043
Gold . . .	0·0006791	Zinc . . .	0·000337
Silver . . .	0·001118	Lead . . .	0·0010[illegible]
Copper (ic) . .	0·0003281		
,, (ous) . .	0·0006562	Oxygen . . .	0·00008286
Mercury (ic) . .	0·0010374	Chlorine . . .	0·0003673
,, (ous) . .	0·0020748	Iodine . . .	0·001314
Tin (ic) . .	0·0003058	Bromine . .	0·0008282
,, (ous) . .	0·0006116	Nitrogen . .	0·0000485

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* The coulomb is the quantity of electricity conveyed by a current of one ampere in one second (also called an ampere-second).

The values given on p. 164 are obtained by multiplying 0·000010384 (the electro-chemical equivalent of hydrogen) by the fraction $\frac{\text{atomic weight}}{\text{valency}}$ of each element.

The prefix meg- means a million times the unit to which it is prefixed.

The prefix micro- means a millionth part of the unit to which it is prefixed.

Thus a megohm is a million ohms, and 1 microvolt is a millionth of a volt.

The watt is the power of a current of 1 ampere flowing under a pressure of 1 volt. It equals $\frac{1}{746}$ of one horse power.

1 kilowatt = 1000 watts = 44,240 ft.-lb. per min.
= 1·34 horse power.

1 electrical horse power = 746 watts = 33,000 ft.-lb. per min.

1 B.T.U. = 3,600,000 watt-seconds, or 36×10^5 watt-seconds.

1 kilowatt-hour = 1·34 horse-power hours.

1 French or metric horse power = 75 kilogrammetres per sec.
= 32,549 ft.-lb. per min.
= 736 watts.
= 0·9863 British horse-power.

1 British horse power = 1·01385 French horse-power (force de cheval).

Board of Trade Unit (B.T.U.). For commercial purposes electrical energy is measured in units of 1000 watt-hours each, known as Board of Trade units.

$$1 \text{ B.T.U.} = \frac{1000}{746} = 1\tfrac{1}{3} \text{ horse power-hours.}$$

RULES FOR THE CONVERSION OF THERMOMETRIC DEGREES FROM ONE SCALE INTO ANOTHER.

To Convert	Rules
° F. into ° C.	First subtract 32, then multiply by 5 and divide by 9.
° F. into ° R.	First subtract 32, then multiply by 4 and divide by 9.
° C. into ° F.	Multiply by 9 and divide by 5, then add 32.
° C. into ° R.	Multiply by 4 and divide by 5.
° R. into ° F.	Multiply by 9 and divide by 4, then add 32.
° R. into ° C.	Multiply by 5 and divide by 4.

Note.—Perhaps the simplest rule for the conversion of °C. into °F. is the following:—

Double the number of degrees, subtract one-tenth, then add 32.

Thus

$$90° \text{ C.} = 90 \times 2 = 180 - 18 = 162 + 32 = 194° \text{ F.}$$

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I.

FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.
500	208	260	452	186·7	233·3	404	165·3	206·7
499	207·6	259·4	451	186·2	232·8	403	164·9	206·1
498	207·1	258·9	450	185·8	232·2	402	161·4	205·6
497	206·7	258·3	449	185·3	231·7	401	164	205
496	206·2	257·8	448	184·9	231·1	400	163·6	204·4
495	205·8	257·2	447	184·4	230·6	399	163·1	203·9
494	205·3	256·7	446	184	230	398	162·7	203·3
493	204·9	256·1	445	183·6	229·4	397	162·2	202·8
492	201·4	255·6	444	183·1	228·9	396	161·8	202·2
491	204	255	443	182·7	228·3	395	161·3	201·7
490	203·6	254·4	442	182·2	227·8	394	160·9	201·1
489	203·1	253·9	441	181·8	227·2	393	160·4	200·6
488	202·7	253·3	440	181·3	226·7	392	160	200
487	202·2	252·8	439	180·9	226·1	391	159·6	199·4
486	201·8	252·2	438	180·4	225·6	390	159·1	198·9
485	201·3	251·7	437	180	225	389	158·7	198·3
484	200·9	251·1	436	179·6	224·4	388	158·2	197·8
483	200·4	250·6	435	179·1	223·9	387	157·8	197·2
482	200	250	434	178·7	223·3	386	157·3	196·7
481	199·6	249·4	433	178·2	222·8	385	156·9	196·1
480	199·1	248·9	432	177·8	222·2	384	156·4	195·6
479	198·7	248·3	431	177·3	221·7	383	156	195
478	198·2	247·8	430	176·9	221·1	382	155·6	194·4
477	197·8	247·2	429	176·4	220·6	381	155·1	193·9
476	197·3	246·7	428	176	220	380	154·7	193·3
475	196·9	216·1	427	175·6	219·4	379	154·2	192·8
474	196·4	245·6	426	175·1	218·9	378	153·8	192·2
473	196	245	425	174·7	218·3	377	153·3	191·7
472	195·6	244·4	424	174·2	217·8	376	152·9	191·1
471	195·1	243·9	423	173·8	217·2	375	152·4	190·6
470	194·7	243·3	422	173·3	216·7	374	152	190
469	194·2	242·8	421	172·9	216·1	373	151·6	189·4
468	193·8	242·2	420	172·4	215·6	372	151·1	188·9
467	193·3	241·7	419	172	215	371	150·7	188·3
466	192·9	241·1	418	171·6	214·4	370	150·2	187·8
465	192·4	240·6	417	171·1	213·9	369	149·8	187·2
464	192	240	416	170·7	213·3	368	149·3	186·7
463	191·6	239·4	415	170·2	212·8	367	148·9	186·1
462	191·1	238·9	414	169·8	212·2	366	148·4	185·6
461	190·7	238·3	413	169·3	211·7	365	148	185
460	190·2	237·8	412	168·9	211·1	364	147·6	184·4
459	189·8	237·2	411	168·4	210·6	363	147·1	183·9
458	189·3	236·7	410	168	210	362	146·7	183·3
457	188·9	236·1	409	167·6	209·4	361	146·2	182·8
456	188·4	235·6	408	167·1	208·9	360	145·8	182·2
455	188	235	407	166·7	208·3	359	145·3	181·7
454	187·6	234·4	406	166·2	207·8	358	144·9	181·1
453	187·1	233·9	405	165·8	207·2	357	144·4	180·6

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I.—*continued.*

FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.
356	144	180	308	122·7	153·3	260	101·3	126·7
355	143·6	179·4	307	122·2	152·8	259	100·9	126·1
354	143·1	178·9	306	121·8	152·2	258	100·4	125·6
353	142·7	178·3	305	121·3	151·7	257	100	125
352	142·2	177·8	304	120·9	151·1	256	99·6	124·4
351	141·8	177·2	303	120·4	150·6	255	99·1	123·9
350	141·3	176·7	302	120	150	254	98·7	123·3
349	140·9	176·1	301	119·6	149·4	253	98·2	122·8
348	140·4	175·6	300	119·1	148·9	252	97·8	122·2
347	140	175	299	118·7	148·3	251	97·3	121·7
346	139·6	174·4	298	118·2	147·8	250	96·9	121·1
345	139·1	173·9	297	117·8	147·2	249	96·4	120·6
344	138·7	173·3	296	117·3	146·7	248	96	120
343	138·2	172·8	295	116·9	146·1	247	95·6	119·4
342	137·8	172·2	294	116·4	145·6	246	95·1	118·9
341	137·3	171·7	293	116	145	245	94·7	118·3
340	136·9	171·1	292	115·6	144·4	244	94·2	117·8
339	136·4	170·6	291	115·1	143·9	243	93·8	117·2
338	136	170	290	114·7	143·3	242	93·3	116·7
337	135·6	169·4	289	114·2	142·8	241	92·9	116·1
336	135·1	168·9	288	113·8	142·2	240	92·4	115·6
335	134·7	168·3	287	113·3	141·7	239	92	115
334	134·2	167·8	286	112·9	141·1	238	91·6	114·4
333	133·8	167·2	285	112·4	140·6	237	91·1	113·9
332	133·3	166·7	284	112	140	236	90·7	113·3
331	132·9	166·1	283	111·6	139·4	235	90·2	112·8
330	132·4	165·6	282	111·1	138·9	234	89·8	112·2
329	132	165	281	110·7	138·3	233	89·3	111·7
328	131·6	164·4	280	110·2	137·8	232	88·9	111·1
327	131·1	163·9	279	109·8	137·2	231	88·4	110·6
326	130·7	163·3	278	109·3	136·7	230	88	110
325	130·2	162·8	277	108·9	136·1	229	87·6	109·4
324	129·8	162·2	276	108·4	135·6	228	87·1	108·9
323	129·3	161·7	275	108	135	227	86·7	108·3
322	128·9	161·1	274	107·6	134·4	226	86·2	107·8
321	128·4	160·6	273	107·1	133·9	225	85·8	107·2
320	128	160	272	106·7	133·3	224	85·3	106·7
319	127·6	159·4	271	106·2	132·8	223	84·9	106·1
318	127·1	158·9	270	105·8	132·2	222	84·4	105·6
317	126·7	158·3	269	105·3	131·7	221	84	105
316	126·2	157·8	268	104·9	131·1	220	83·6	104·4
315	125·8	157·2	267	104·4	130·6	219	83·1	103·9
314	125·3	156·7	266	104	130	218	82·7	103·3
313	124·9	156·1	265	103·6	129·4	217	82·2	102·8
312	124·4	155·6	264	103·1	128·9	216	81·8	102·2
311	124	155	263	102·7	128·3	215	81·3	101·7
310	123·6	154·4	262	102·2	127·8	214	80·9	101·1
309	123·1	153·9	261	101·8	127·2	213	80·4	100·6

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I.—*continued*

FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.
212	80·0	100·0	164	58·7	73·3	116	37·3	46·7
211	79·6	99·4	163	58·2	72·8	115	36·9	46·1
210	79·1	98·9	162	57·8	72·2	114	36·4	45·6
209	78·7	98·3	161	57·3	71·7	113	36·0	45·0
208	78·2	97·8	160	56·9	71·1	112	35·6	44·4
207	77·8	97·2	159	56·4	70·6	111	35·1	43·9
206	77·3	96·7	158	56·0	70·0	110	34·7	43·3
205	76·9	96·1	157	55·6	69·4	109	34·2	42·8
204	76·4	95·6	156	55·1	68·9	108	33·8	42·2
203	76·0	95·0	155	54·7	68·3	107	33·3	41·7
202	75·6	94·4	154	54·2	67·8	106	32·9	41·1
201	75·1	93·9	153	53·8	67·2	105	32·4	40·6
200	74·7	93·3	152	53·3	66·7	104	32·0	40·0
199	74·2	92·8	151	52·9	66·1	103	31·6	39·4
198	73·8	92·2	150	52·4	65·6	102	31·1	38·9
197	73·3	91·7	149	52·0	65·0	101	30·7	38·3
196	72·9	91·1	148	51·6	64·4	100	30·2	37·8
195	72·4	90·6	147	51·1	63·9	99	29·8	37·2
194	72·0	90·0	146	50·7	63·3	98	29·3	36·7
193	71·6	89·4	145	50·2	62·8	97	28·9	36·1
192	71·1	88·9	144	49·8	62·2	96	28·4	35·6
191	70·7	88·3	143	49·3	61·7	95	28·0	35·0
190	70·2	87·8	142	48·9	61·1	94	27·6	34·4
189	69·8	87·2	141	48·4	60·6	93	27·1	33·9
188	69·3	86·7	140	48·0	60·0	92	26·7	33·3
187	68·9	86·1	139	47·6	59·4	91	26·2	32·8
186	68·4	85·6	138	47·1	58·9	90	25·8	32·2
185	68·0	85·0	137	46·7	58·3	89	25·3	31·7
184	67·6	84·4	136	46·2	57·8	88	24·9	31·1
183	67·1	83·9	135	45·8	57·2	87	24·4	30·6
182	66·7	83·3	134	45·3	56·7	86	24·0	30·0
181	66·2	82·8	133	44·9	56·1	85	23·6	29·4
180	65·8	82·2	132	44·4	55·6	84	23·1	28·9
179	65·3	81·7	131	44·0	55·0	83	22·7	28·3
178	64·9	81·1	130	43·6	54·4	82	22·2	27·8
177	64·4	80·6	129	43·1	53·9	81	21·8	27·2
176	64·0	80·0	128	42·7	53·3	80	21·3	26·7
175	63·6	79·4	127	42·2	52·8	79	20·9	26·1
174	63·1	78·9	126	41·8	52·2	78	20·4	25·6
173	62·7	78·3	125	41·3	51·7	77	20·0	25·0
172	62·2	77·8	124	40·9	51·1	76	19·6	24·4
171	61·8	77·2	123	40·4	50·6	75	19·1	23·9
170	61·3	76·7	122	40·0	50·0	74	18·7	23·3
169	60·9	76·1	121	39·6	49·4	73	18·2	22·8
168	60·4	75·6	120	39·1	48·9	72	17·8	22·2
167	60·0	75·0	119	38·7	48·3	71	17·3	21·7
166	59·6	74·4	118	38·2	47·8	70	16·9	21·1
165	59·1	73·9	117	37·8	47·2	69	16·4	20·6

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I.—*continued.*

FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.
68	16·0	20·0	34	0·9	1·1	0	-14·2	-17·8
67	15·6	19·4	33	0·4	0·6	-1	-14·7	-18·3
66	15·1	18·9	32	0·0	0·0	-2	-15·1	-18·9
65	14·7	18·3	31	-0·4	-0·6	-3	-15·6	-19·4
64	14·2	17·8	30	-0·9	-1·1	-4	-16·0	-20·0
63	13·8	17·2	29	-1·3	-1·7	-5	-16·4	-20·6
62	13·3	16·7	28	-1·8	-2·2	-6	-16·9	-21·1
61	12·9	16·1	27	-2·2	-2·8	-7	-17·3	-21·7
60	12·4	15·6	26	-2·7	-3·3	-8	-17·8	-22·2
59	12·0	15·0	25	-3·1	-3·9	-9	-18·2	-22·8
58	11·6	14·4	24	-3·6	-4·4	-10	-18·7	-23·3
57	11·1	13·9	23	-4·0	-5·0	-11	-19·1	-23·9
56	10·7	13·3	22	-4·4	-5·6	-12	-19·6	-24·4
55	10·2	12·8	21	-4·9	-6·1	-13	-20·0	-25·0
54	9·8	12·2	20	-5·3	-6·7	-14	-20·4	-25·6
53	9·3	11·7	19	-5·8	-7·2	-15	-20·9	-26·1
52	8·9	11·1	18	-6·2	-7·8	-16	-21·3	-26·7
51	8·4	10·6	17	-6·7	-8·3	-17	-21·8	-27·2
50	8·0	10·0	16	-7·1	-8·9	-18	-22·2	-27·8
49	7·6	9·4	15	-7·6	-9·5	-19	-22·7	-28·3
48	7·1	8·9	14	-8·0	-10·0	-20	-23·1	-28·9
47	6·7	8·3	13	-8·4	-10·6	-21	-23·6	-29·4
46	6·2	7·8	12	-8·9	-11·1	-22	-24·0	-30·0
45	5·8	7·2	11	-9·3	-11·7	-23	-24·4	-30·6
44	5·3	6·7	10	-9·8	-12·2	-24	-24·9	-31·1
43	4·9	6·1	9	-10·2	-12·8	-25	-25·3	-31·7
42	4·4	5·6	8	-10·7	-13·3	-26	-25·8	-32·2
41	4·0	5·0	7	-11·1	-13·9	-27	-26·2	-32·8
40	3·6	4·4	6	-11·6	-14·4	-28	-26·7	-33·3
39	3·1	3·9	5	-12·0	-15·0	-29	-27·1	-33·9
38	2·7	3·3	4	-12·4	-15·6	-30	-27·6	-34·4
37	2·2	2·8	3	-12·9	-16·1	-31	-28·0	-35·0
36	1·8	2·2	2	-13·3	-16·7			
35	1·3	1·7	1	-13·8	-17·2			

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE II.

CENT.	Reaum.	Fahr.	CENT.	Reaum.	Fahr.	CENT.	Reaum.	Fahr.
260	208	500	252	201·6	485·6	244	195·2	471·2
259	207·2	498·2	251	200·8	483·8	243	194·4	469·4
258	206·4	496·4	250	200	482	242	193·6	467·6
257	205·6	494·6	249	199·2	480·2	241	192·8	465·8
256	204·8	492·8	248	198·4	478·4	240	192	464
255	204	491	247	197·6	476·6	239	191·2	462·2
254	203·2	489·2	246	196·8	474·8	238	190·4	460·4
253	202·4	487·4	245	196	473	237	189·6	458·6

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE II.—*continued.*

Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.
236	188·8	456·8	188	150·4	370·4	140	112	284
235	188	455	187	149·6	368·6	139	111·2	282·2
234	187·2	453·2	186	148·8	366·8	138	110·4	280·4
233	186·4	451·4	185	148	365	137	109·6	278·6
232	185 6	419·6	184	147·2	363·2	136	108·8	276·8
231	184·8	447·8	183	146·4	361·4	135	108	275
230	184	446	182	145·6	359·6	134	107·2	273·2
229	183·2	444·2	181	144·8	357·8	133	106·4	271·4
228	182·4	412·4	180	144	356	132	105·6	269·6
227	181·6	440·6	179	143·2	354·2	131	104·8	267 8
226	180·8	438·8	178	142·4	352·4	130	104	266
225	180	437	177	141 6	350·6	129	103·2	264·2
224	179·2	435·2	176	140·8	348·8	128	102·4	262·4
223	178·4	433·4	175	140	347	127	101·6	260·6
222	177·6	431·6	174	139·2	345·2	126	100·8	258·8
221	176·8	429·8	173	138·4	343·4	125	100	257
220	176	428	172	137·6	341·6	124	99·2	255·2
219	175·2	426·2	171	136·8	339·8	123	98·4	253·4
218	174·4	424·4	170	136	338	122	97·6	251·6
217	173·6	422·6	169	135·2	336·2	121	96·8	249·8
216	172·8	420·8	168	134·4	334·4	120	96	248
215	172	419	167	133·6	332·6	119	95·2	246·2
214	171·2	417·2	166	132·8	330·8	118	94·4	244·4
213	170·4	415·4	165	132	329	117	93·6	242·6
212	169·6	413·6	164	131·2	327·2	116	92·8	240·8
211	168·8	411·8	163	130·4	325·4	115	92	239
210	168	410	162	129·6	323·6	114	91·2	237·2
209	167·2	408·2	161	128·8	321·8	113	90·4	235·4
208	166·4	406·4	160	128	320	112	89·6	233·6
207	165·6	404·6	159	127·2	318·2	111	88·8	231·8
206	164·8	402·8	158	126·4	316·4	110	88	230
205	164	401	157	125·6	314·6	109	87·2	228·2
204	163·2	399·2	156	124·8	312·8	108	86·4	226·4
203	162·4	397·4	155	124	311	107	85·6	224·6
202	161·6	395·6	154	123·2	309·2	106	84·8	222·8
201	160·8	393·8	153	122·4	307·4	105	84	221
200	160	392	152	121·6	305·6	104	83·2	219·2
199	159·2	390·2	151	120·8	303·8	103	82·4	217·4
198	158·4	388·4	150	120	302	102	81·6	215·6
197	157·6	386·6	149	119·2	300·2	101	80·8	213·8
196	156·8	384·8	148	118·4	298·4	100	80	212
195	156	383	147	117·6	296·6	99	79·2	210·2
194	155·2	381·2	146	116·8	294·8	98	78·4	208·4
193	154·4	379·4	145	116	293	97	77·6	206·6
192	153·6	377·6	144	115·2	291·2	96	76·8	204·8
191	152·8	375·8	143	114·4	289·4	95	76	203
190	152	374	142	113·6	287·6	94	75·2	201·2
189	151·2	372·2	141	112·8	285·8	93	74·4	199·4

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE II.—*continued.*

CENT.	Reaum.	Fahr.	CENT.	Reaum.	Fahr.	CENT.	Reaum.	Fahr.
92	73·6	197·6	49	39·2	120·2	6	4·8	42·8
91	72·8	195·8	48	38·4	118·4	5	4	41
90	72	194	47	37·6	116·6	4	3·2	39·2
89	71·2	192·2	46	36·8	114·8	3	2·4	37·4
88	70·4	190·4	45	36	113	2	1·6	35·6
87	69·6	188·6	44	35·2	111·2	1	0·8	33·8
86	68·8	186·8	43	34·4	109·4	0	0	32
85	68	185	42	33·6	107·6	- 1	- 0·8	30·2
84	67·2	183·2	41	32·8	105·8	- 2	- 1·6	28·4
83	66·4	181·4	40	32	104	- 3	- 2·4	26·6
82	65·6	179·6	39	31·2	102·2	- 4	- 3·2	24·8
81	64·8	177·8	38	30·4	100·4	- 5	- 4	23
80	64	176	37	29·6	98·6	- 6	- 4·8	21·2
79	63·2	174·2	36	28·8	96·8	- 7	- 5·6	19·4
78	62·4	172·4	35	28	95	- 8	- 6·4	17·6
77	61·6	170·6	34	27·2	93·2	- 9	- 7·2	15·8
76	60·8	168·8	33	26·4	91·4	- 10	- 8	14
75	60	167	32	25·6	89·6	- 11	- 8·8	12·2
74	59·2	165·2	31	24·8	87·8	- 12	- 9·6	10·4
73	58·4	163·4	30	24	86	- 13	- 10·4	8·6
72	57·6	161·6	29	23·2	84·2	- 14	- 11·2	6·8
71	56·8	159·8	28	22·4	82·4	- 15	- 12	5
70	56	158	27	21·6	80·6	- 16	- 12·8	3·2
69	55·2	156·2	26	20·8	78·8	- 17	- 13·6	1·4
68	54·4	154·4	25	20	77	- 18	- 14·4	- 0·4
67	53·6	152·6	24	19·2	75·2	- 19	- 15·2	- 2·2
66	52·8	150·8	23	18·4	73·4	- 20	- 16	- 4
65	52	149	22	17·6	71·6	- 21	- 16·8	- 5·8
64	51·2	147·2	21	16·8	69·8	- 22	- 17·6	- 7·6
63	50·4	145·4	20	16	68	- 23	- 18·4	- 9·4
62	49·6	143·6	19	15·2	66·2	- 24	- 19·2	- 11·2
61	48·8	141·8	18	14·4	64·4	- 25	- 20	- 13
60	48	140	17	13·6	62·6	- 26	- 20·8	- 14·8
59	47·2	138·2	16	12·8	60·8	- 27	- 21·6	- 16·6
58	46·4	136·4	15	12	59	- 28	- 22·4	- 18·4
57	45·6	134·6	14	11·2	57·2	- 29	- 23·2	- 20·2
56	44·8	132·8	13	10·4	55·4	- 30	- 24	- 22
55	44	131	12	9·6	53·6	- 31	- 24·8	- 23·8
54	43·2	129·2	11	8·8	51·8	- 32	- 25·6	- 25·6
53	42·4	127·4	10	8	50	- 33	- 26·4	- 27·4
52	41·6	125·6	9	7·2	48·2	- 34	- 27·2	- 29·2
51	40·8	123·8	8	6·4	46·4	- 35	- 28	- 31
50	40	122	7	5·6	44·6			